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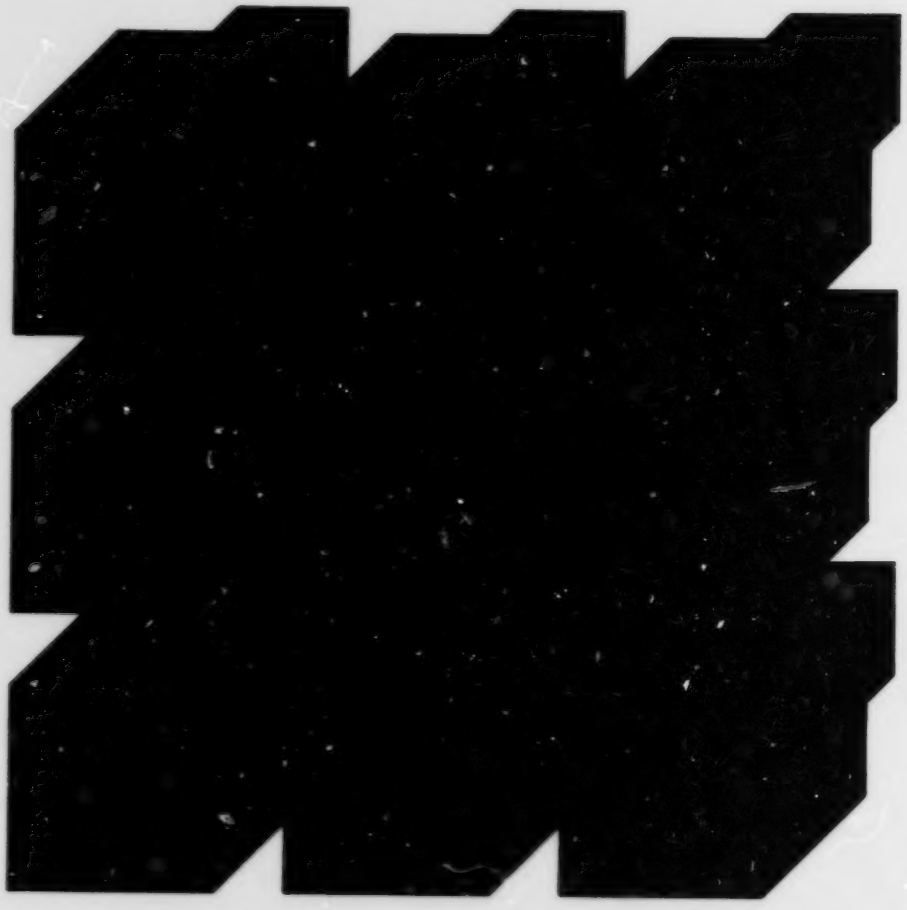

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DISCUSSION PAPER NO. 270

Exhaustible Resources and Economic Growth: the Case of Uranium Mining in Saskatchewan

by Harry F. Campbell

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Table of Contents

Chapter		
0	Introduction and Summary	
1	Exhaustible Resources and Growth	
	(i)	Introduction
	(ii)	Booming Sector Economics
	(iii)	Resource Booms and Migration
	(iv)	Exhaustibility and Future Generations
	(v)	Government Policy Towards a Resources Boom
2	Collecting Mineral Rent	
	(i)	Introduction
	(ii)	The Effects of Mineral Taxation - a brief survey
	(iii)	Neutrality of the Saskatchewan Uranium Royalty
	(iv)	Efficiency, Effectiveness and the Extraction Plan for the Key Lake Mine
3	The Economic Impact of Uranium Mining in Saskatchewan	
	(i)	Introduction
	(ii)	Saskatchewan's Uranium Reserves
	(iii)	Restrictions on Development Imposed by Government Policy
	(iv)	The Uranium Cartel
	(v)	The World Uranium Market and Canadian Production
	(vi)	The Impact of Uranium Production on the Economy of Saskatchewan

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RÉSUMÉ

L'auteur de l'étude examine l'effet de l'essor du secteur primaire sur la croissance économique régionale, et s'intéresse particulièrement aux répercussions de la politique des administrations régionales sur l'imposition des rentes sur les ressources minières et la répartition des recettes tirées des ressources. Il étaye tout d'abord la théorie pertinente et l'applique ensuite au cas de l'industrie de l'uranium en Saskatchewan.

Dans le premier chapitre, l'auteur s'inspire d'un modèle pour illustrer l'effet de l'essor du secteur primaire sur la structure industrielle et sur les coûts et la répartition des facteurs. Les gouvernements soutiennent souvent qu'une part importante des rentes découlant de l'essor du secteur primaire devrait revenir au secteur public. L'auteur explique les arguments habituels d'efficience et d'équité et se penche sur leur applicabilité à l'industrie de l'uranium de la Saskatchewan. Le modèle est élargi afin d'englober les politiques provinciales en matière d'imposition et de dépenses. Dans le deuxième chapitre, l'auteur s'intéresse aux taxes sur les ressources minières et analyse leurs divers effets sur le comportement des entreprises sur les plans de l'exploration et de l'extraction. Encore une fois, la théorie est examinée et utilisée par la suite pour prévoir l'effet des taxes sur l'indutrie de l'uranium. La redevance imposée par la Saskatchewan sur l'uranium est explicitement examinée dans un modèle quantitatif afin d'analyser son effet sur le taux d'extraction à la mine Key Lake. Dans ces chapitres, l'auteur appuie

l'argument de l'équité des rentes perçues sur les ressources, mais pose certaines objections à l'argument d'efficacité. Il convient que les taxes perçues par le gouvernement de la Saskatchewan sont de nature corrective, c'est-à-dire qu'elles réduisent le taux d'extraction et qu'elles compensent certaines lacunes du marché et permettent une utilisation plus efficiente des ressources. Il n'admet pas cependant que la répartition de ces taxes contribuent à l'efficience économique. La politique du gouvernement provincial fait en sorte que les résidants bénéficient d'avantages sous la forme d'une réduction des impôts et d'une baisse des prix des biens et services fournis par l'État. Les gens sont encouragés à déménager en Saskatchewan et la réaffectation de la main-d'oeuvre qui en résulte entraîne une perte au poste du bien-être.

Dans le troisième chapitre, l'auteur entrevoit d'abondantes réserves d'uranium exploitables à peu de frais, mais il prévoit que la politique gouvernementale en limitera la rapidité d'expansion. Compte tenu de ces facteurs et de la situation du marché mondial de l'uranium, l'auteur établit des prévisions de la production d'uranium et estime les répercussions de l'industrie sur la croissance économique de la Saskatchewan. La contribution de l'industrie au produit intérieur brut provincial en l'an 2000 pourrait atteindre 10 % du niveau de 1980 du PIbP, et sa contribution à l'emploi pourrait s'élever à 9 % de l'emploi non agricole de 1980. Un avertissement au lecteur précise que l'analyse est très spéculative et que ces pourcentages sont probablement surestimés.

ABSTRACT

This study examines the effect of a booming natural resource sector on regional economic growth, with particular attention to the impact of regional government policy on mineral rent taxation and the allocation of resource revenues. The author's approach is first to document the relevant theory and then to apply it to the case of the uranium industry in Saskatchewan.

Chapter 1 draws on a model to illustrate the effect of a resource boom on industrial structure and on factor prices and allocation. Governments often hold the view that a significant portion of resource rents flowing from the boom should be appropriated by the public sector. The usual arguments of efficiency and equity are explained, as is their applicability to uranium in Saskatchewan. The model is extended to include provincial tax and expenditure policies. Chapter 2 concentrates on mineral taxes and examines their various effects on the behaviour of firms with respect to exploration and extraction. Again the theory is reviewed and is subsequently used to anticipate the effect of taxes on uranium mining. The Saskatchewan Uranium Royalty is explicitly considered in a quantitative model to analyse the effect on the rate of extraction on the Key Lake Mine. These chapters support the equity argument for collecting resource rents but have some objections to the efficiency argument. It is agreed that taxes collected by the Saskatchewan government are corrective in nature in that they lower the rate of extraction and make up for certain market failures and improve efficiency of resource use. It is not

accepted, however, that the allocation of these taxes contributes to economic efficiency. Provincial government policy is such that benefits to residents in the form of lower taxes and low prices for publicly supplied goods and services. An incentive is created for persons to move to Saskatchewan and the resulting reallocation of labour creates a welfare loss.

Chapter 3 foresees plentiful low cost uranium reserves but judges that government policy will limit rapid expansion. Weighing these factors and the world uranium market, uranium production forecasts are derived and an estimate is made of the impact of the industry on economic growth in Saskatchewan. The contribution to Gross Domestic Provincial Product in 2000 could be as high as 10% of the 1980 GDPP level and the contribution to employment as high as 9% of 1980 nonagricultural employment. The reader is cautioned that the analysis is extremely speculative and that these percentages are very likely over estimated.

0. Introduction and Summary

The subject of this study is the effect of a booming natural resource sector on resource allocation and regional economic development, taking account of the tax and expenditure policies of the regional government. The analysis is conducted in the context of the impact of the uranium industry on the economy of Saskatchewan given provincial government policy on mineral rent taxation and the disposition of resource revenues. Chapter 1 considers the regional impact of a booming resource sector: it reviews the literature on the effect of a resources boom on factor prices and industrial structure, taking particular account of the effect of government expenditure of resource rent tax receipts. Chapter 2 reviews the effects on mineral extraction rates of various methods of collecting resource rents. The effect of the Saskatchewan Uranium Royalty is analysed by means of a model of the Key Lake Mine. In Chapter 3 some forecasts of Saskatchewan uranium production and price are presented and are used to predict the impact of the uranium industry on Gross Domestic Provincial Product (GDPP) to the year 2020. It is emphasized that these forecasts are at best speculative and are likely subject to an upward bias. The analysis reveals the critical role of provincial government policy in determining the effect of the expansion of the industry on resource allocation and the provincial economy.

The first two chapters of the study are concerned with the equity and efficiency of a system of resource rent taxation and expenditure. It is argued on equity grounds that the public sector should impose some kind of levy on the mineral industry for the use of exhaustible resources which are in the public domain. In the absence of such a levy the share of resource rents accruing to foreigners and the distribution of resource rents within the country resulting from the interplay of market forces is unlikely to accord with the public's view

of an equitable distribution. The general tax system with no special levies on resource rents is unable to cope with the requirement of public policy that resource rents accrue to the public sector as resource owner.

Once it is accepted that resource rents will be collected for reasons of equity, two considerations of economic efficiency arise. The first relates to the efficiency effects of collecting resource rents, and the second to the efficiency effects of the public sector's expenditure of resource income. As far as the efficiency effects of resource rent collection schemes is concerned there are two opposing views, one that the taxes are corrective in nature and the other that they impose a welfare loss on the economy. The investigation of the latter contention in Chapter 2 of the study reveals that even if there were no corrective role for mining taxes the deadweight loss resulting from the Saskatchewan Uranium Royalty would be very slight, amounting in the case of the Key Lake Mine to something in the order of 3% of net present value. There are two principle reasons for supposing that the system of uranium royalties serves a corrective function both of which are consequent upon the system's effect in lowering the rate of extraction of the mineral. Firstly, Canada, in conjunction with other non-communist world producers outside of the United States, has some degree of market power and a lowering of the rate of uranium production and sales serves to increase the price received and thereby to improve the efficiency of resource use from a national viewpoint. Secondly, there is reason to believe that various market imperfections and failures in the regional economy may be at least partially offset by a lower rate of uranium extraction. The areas of market failure are the environmental effects of uranium mining and the market imperfections relate to the access of northern residents to the labour market.

The expenditure of resource revenues by the taxing jurisdiction need not in principle result in allocative inefficiency. The distribution of capitalized resource rents on a once-and-for-all poll basis would satisfy the efficiency criterion While such a use of Alberta's oil revenues has been proposed it is unlikely to achieve political acceptance because it involves an abdication of power on the part of the provincial government and, from the point of view of residents of other areas of the country, it is too blatantly self-serving. The resource rich provinces have chosen a middle ground which involves a combination of saving the proceeds obtained from depleting resource capital and spending them on public and private goods within the province. In order to obtain a share of the public sector benefits resulting from uranium mining in Saskatchewan an individual must reside in that province because provincial government policy results in benefits taking the form of lower taxes and lower prices for publicly supplied goods and services to residents. This policy, therefore, creates an incentive for citizens of other parts of Canada to move to Saskatchewan in order to share in the mineral development. The resulting reallocation of labour creates a welfare loss which can be regarded as a special form of resource rent dissipation.

The impact of the uranium industry on GDPP in the year 2000, for example, is estimated in Chapter 3 to be almost 10% of the 1980 GDPP level. This estimate should probably be regarded as an upper bound as it is based on optimistic production forecasts and on an extreme estimate of the provincial income multiplier. A higher estimate, on the other hand, could have been obtained by assuming that all uranium royalties were used to increase general provincial government expenditure instead of being divided equally among general expenditures, development expenditures, and tax cuts. If the provincial government sterilized resource revenues by investing them outside the province and reinvesting the

interest, and if the more pessimistic production forecasts were adopted the impact on GDPP in the year 2000 could be less than 5¼% of 1980 GDPP. The industry's impact on employment in the year 2000 could be as high as 9% of total 1980 nonagricultural employment in the province on the basis of the optimistic production forecasts, the assumptions about the disposition of uranium royalties, and the exaggerated provincial income multiplier. On the other hand, if uranium revenues were sterilized and the pessimistic production forecasts were adopted the impact on employment could be as low as 2% of 1980 nonagricultural employment.

While the estimates of the uranium industry's impact on GDPP are expressed in terms of real 1980 dollars, there is some reason to believe that even if the uranium price and production estimates, the assumptions about the disposition of revenues, and the estimate of the multiplier used were accurate the estimates of impact on real GDPP would be too high. It must be expected that the resources boom and its attendent increase in government expenditure will increase wages and costs in Saskatchewan. The higher level of production costs means that the estimates of impact on real GDPP, which are based on the assumption of constant factor prices, are too high. Of course the rise in wages necessary to attract labour from outside the province will be tempered by the government's policy of using uranium revenues to subsidize consumption of publicly produced goods. On the basis of the principle of equal net advantage the wage level and hence the marginal product of labour in Saskatchewan will tend to become lower than in the regions of out-migration. This means that any increases in real output in Saskatchewan may be more than offset by reductions in real output in other parts of the country.

The author's personal conclusion is that resource rents should be taxed for reasons of equity but that they should not be used to finance provincial government expenditure. Rather they should be distributed to the population of the nation as a whole in some relatively nondistorting fashion such as a cut in federal income tax rates. This would allow private individuals to base decisions on where to live on factors reflecting economic efficiency. If resource revenues were distributed as they accrue this policy would also allow private individuals to decide how much should be saved for the future. Alternatively saving for future generations could be accomplished by sterilizing a portion of resource revenues in the manner described above and the resulting income flow could be distributed through income tax reduction.

1 Exhaustible Resources and Economic Growth

1. (i) Introduction

In this subsection some of the literature on the contribution of mineral resources to economic growth is reviewed. In subsection (ii) the effect of a resource discovery or price increase on other sectors of the economy is described in the context of a simple three-sector model with fixed total supply of labour. One of the most significant effects of a resources boom is to encourage in migration of labour and this issue is examined in subsection (iii) using the results of models of fiscal equalization programmes and assuming that the provincial government collects and spends resource revenues. One use to which resource revenues have been put in Saskatchewan and Alberta is the provision of nonresource capital for the benefit of future residents. Subsection (iv) looks at the principle and practice of this allocation of funds. Subsection (v) describes provincial policy objectives in more detail and reviews the predictions of a six sector provincial economy model incorporating inmigration about the effects of provincial tax and expenditure policies.

1. (ii) Booming Sector Economics

There has recently been a considerable amount of economic analysis of the effects of a resources boom on the other sectors of the economy. Much of the work concerns the effect of the oil boom on the economies of the OPEC countries, Holland, the UK, Western Canada but there are also studies of the effects of mineral booms in Australia and of resources booms in general. Corden (1982) has written a survey of some forty recent papers on this topic. The present survey describes only those aspects of Corden's study which are particularly relevant to the impact of the uranium boom on the Saskatchewan economy.

The standard model in booming sector economics has three sectors. The booming sector (B) produces tradeables using a specific factor, such as natural resources and industry specific capital, and a nonspecific factor, such as labour, which is mobile among the three sectors so that its wage in all three is the same. The "boom" is caused either by an increase in the exogenously determined world price of good B, as in the case of Saskatchewan's oil, or by a windfall increase in the quantity of the specific factor available to industry B, as in the case of Saskatchewan's uranium. The lagging sector (L) also produces tradeables using a specific factor, such as capital, and the nonspecific mobile factor and, like the booming sector it faces an exogenously determined world price. The nontradeable sector (N) produces goods using a specific factor and the mobile factor. Home and foreign produced goods are assumed to be perfect substitutes and the economy's factor stock is assumed to be fixed.

This simple model, and its many variants, can be used to analyse the effects of a resource boom. There are two types of effects referred to as the

spending effect and the resource movement effect. The resources boom is assumed to generate additional income in sector B. In the case of mineral discoveries resulting from exploration the value of the finds are well in excess of exploration costs so that substantial rents are created. Much is made in the literature about whether this additional income accrues to factor owners or to the government but for the moment this issue can be set aside. Whatever the distribution of the additional income some is assumed to be spent on good N causing excess demand, a rise in price, and an increase in output of good N. In a small open economy, the rise in price of good N represents a real appreciation of the exchange rate. Extra output of good N is obtained by a shift of the mobile factor (labour) from sectors B and L. Of course there may also be additional demand for the products of sectors B and L but any change in the excess demand over domestic supply can be met by reduced exports or increased imports at constant world prices. To the extent that additional spending falls short of additional income a trade surplus will develop. In the case of a region like Saskatchewan a trade surplus would tend to be eliminated in the long-run by price and income increases within and factor migration to the province. In summary, the spending effect results in growth of the nontradeable sector at the expense of the tradeable sectors.

When the supply or price of natural resources increases the value of the marginal product of the mobile factor, labour, increases and labour moves out of the L and N sectors and into the B sector. The consequent reduction in output of good N increases the excess demand for that good resulting from the spending effect and causes a further increase in the price of N and a movement of labour from L to N. This further reduction in the output of sector L caused

by the reallocation of factors of production within the economy is termed the resource movement effect.

The foregoing is a general description of a model with many special cases. Some of these cases which may be relevant to the experience of a region undergoing a resources boom are briefly described here. It is possible that the economy will experience only one of the effects described above. For example, if the B sector does not employ any of the mobile factor, labour, then there will be no resource movement effect; if all goods are tradeable then there is no spending effect as all changes in demand can be accommodated by trade. Another possibility is that capital will not be specific to the L and N sectors but will move between them. In this case the result of labour moving out of L and N and into B, the resource movement effect, will be to expand whichever of L and N is the more capital intensive. Of course this resource movement effect could be offset by a spending effect. It is possible that capital will not be mobile among the sectors of the economy but will be mobile as between each sector and the rest of the world. In the case of perfect capital mobility there will be no change in the price of L assuming constant returns to scale and mobile labour between sectors. The price of N will also be fixed in these circumstances and all changes in demand will be absorbed by output changes with no change in the real exchange rate.

One of the principal concerns in studies of regional resource booms is their effect on real wage levels. It is often not possible to conclude whether the real wage has risen or fallen in a booming sector model of the kind described above. Any change in the real wage will result from a change in the nominal wage and changes in factor prices and these are usually such that while the real wage in terms of one commodity has risen, it has fallen in terms of the other.

A price index derived from labour's utility function would be necessary to conclude whether the welfare of labour had been increased.

In analysing the question of whether regional wage disparities can be attributed to regional differences in resource endowment, Copithorne (1979) arrives at the extreme view that the wage level will not be affected by a resource discovery in a region provided that the region is not driven to complete specialization. As long as there is a gadget industry operating at constant returns to scale and selling its output at a fixed price in the world market labour can be drawn from this sector into the booming sector without any increase in its wage. If the increase in the resource endowment is large enough to drive the region to specialize completely in the resource based product there will be a tendency for wages to increase but this tendency, Copithorne argues, will be offset by inmigration. The problem with this argument, as Norrie and Percy (1982) point out is that there is no equilibrating process: a perfectly elastic supply of migrants confronts the perfectly elastic demand for labour of the gadget industry. In other work Copithorne (1981) avoids this problem by postulating a declining demand curve for labour employed in a continuum of industries with declining regional comparative advantage. This is also the approach adopted in the Norrie and Percy (1982) paper which will be discussed in subsection (v).

1. (iii) Resource Booms and Migration

The main reason for the focus of attention on the effect of resource booms in causing migration is that a sequence of resource discovery, migration, resource exploitation and economic growth has been observed time and time again in the study of economic development (for example, see Marr and Paterson (1980, Chapters 3 and 11) and Maddock and McLean (1983)). While there may be special circumstances in which a resource boom in a region does not affect regional wage levels it appears from the historical evidence that this is the exception rather than the rule.

When labour reallocates itself geographically and across industries in reponse to the wage changes that result from a resources boom it is following a prescription of neoclassical economic theory for efficient allocation of resources. An exception is the case in which the migrant's expectations as to future wage levels and employment prospects are not founded on the best information available at the time of the move. An example might be labour moving to a mining community without having accurate information about, or a realistic assessment of the life expectancy of the mine. Another example is the migration of labour in response to signals other than the wage levels paid by industries in the booming region.

One article of faith held by governments presiding over a resource boom is that a significant portion of resource rents should be appropriated by the public sector. This is sometimes justified on efficiency grounds and sometimes on grounds of equity. The efficiency argument is that a resource subject to open access, such as a fishery or a new mineral territory, will attract other factors

of production beyond the point at which marginal social benefits and costs are equalized unless the public sector appropriates the rent thereby removing the incentive for excessive entry. The equity argument is that as owner of a resource the public sector is responsible for ensuring that the use of the resource is such as to benefit society in general and future generations as well as today's. Whatever the rationale for rent collection the fact remains that revenues obtained from a natural resource exploiting industry have to be disposed of in some fashion. In other words, the market distribution of returns is replaced by some other distribution which may result in an inefficient allocation of resources.

There is a literature on fiscally induced migration which examines the effect of federal equalization policies on the allocation of labour. Briefly, the argument is that if the federal government helps poorer provinces to maintain lower tax levels and/or a higher level of expenditure on government provided goods and services than would otherwise be possible the value of the marginal product of labour will not be equalized across regions. The reason for this is that the real wage in the poorer region consists of the nominal wage, or value of the marginal product, plus the value of subsidy on living standards afforded by the federal transfer. Since migration equalizes real wages, net of any costs of adjustment, the value of the marginal product of labour will be lower in poorer than in richer regions in equilibrium and, consequently, the value of national product is reduced by the government's policy. It should be noted that the equalization policy is only one of a number of policies designed to help residents of poorer regions and which have similar effects on the allocation of resources.

The fiscal effects of a resources boom may be similar to those of the equalization programme except that the result will be too much rather than too little migration. When a government such as that of Alberta or Saskatchewan collects large amounts of revenue from its oil or uranium industry it is unlikely that those revenues can be used in a way which leaves unaltered economic incentives consistent with economic efficiency. Two uses of the revenues which would not lead to economic inefficiency are to "privatize" the revenues by allocating them in some arbitrary fashion (for example, to provincial residents as of some date in the past) or to sterilize them by investing them on the money market and not drawing any return from the investment. The former of these proposals, if considered, has already been rejected as politically infeasible by the governments of Alberta and Saskatchewan, while the view that the latter proposal would actually be carried out even if adopted is sufficiently implausible to generate expectations which would result in factor movements inconsistent with economic efficiency. If these two alternatives are rejected then the funds will be used to acquire goods and, in the absence of charity, these will be to the benefit of residents of the province and will encourage in-migration.

The resource revenues are used to acquire both publicly and privately owned investment and consumption goods. For example, the Alberta and Saskatchewan Heritage Funds invest in crown corporations and in private enterprise through subsidized loans; the Alberta Fund has recently been used to subsidize the costs of private housing; and in both Alberta and Saskatchewan resource revenues are used to a significant extent to subsidize publicly supplied consumption services. The result of these uses of resource revenue is an over-allocation of both

labour and capital to the jurisdictions concerned. In-migration of labour is predicted to result from the subsidization of government services so that the nominal wage and the value of the marginal product of labour will be lower in these regions than elsewhere. Subsidized loans and cheap labour will attract capital with a higher value of the marginal product elsewhere. The net effect is a dissipation of resource rent akin to that which is predicted to occur in an open-access fishery and for very similar reasons.

In summary, the economic rents resulting from a resources boom appear to present a political and economic conundrum: equity dictates that the rents be collected but that they not be put to the narrow and selfish uses consistent with economic efficiency; efficiency may require that rents be collected to prevent their dissipation by the private sector but political necessity many cause them to be dissipated by the public sector. Before drawing the conclusion that natural resource revenues constitute an embarrassment of riches it is necessary to recall that provincial governments are not solely or perhaps even mainly interested in economic efficiency. The following two subsections examine some of these goals and to what extent they may be furthered by the kinds of expenditures described here. Subsection (iv) deals with the government's obligation to generations living beyond the date at which a nonrenewable resource is exhausted, while subsection (v) deals with a variety of objectives which collectively can be termed "province building".

1. (iv) Exhaustibility and Future Generations

The mineral resources of a particular grade or quality within a province are exhaustible. This means that as the higher quality deposits are used up it becomes increasingly more expensive to find and produce the mineral in question. Eventually production costs may rise to a level at which the industry cannot compete with lower cost industries elsewhere and shuts down. This presumably will be the eventual fate of Saskatchewan's oil, potash and uranium industries. The question arises as to what provision the current users of the resource should make for generations which will be living after the resource has been exhausted.

A mineral stock is a capital good which by itself yields no utility. It does, however, tend to increase in value over time as mineral prices rise and production costs decline. It makes sense to hold capital in this form as long as the return it earns is at least as high as that in an alternative use. If the province's lending and borrowing rates of interest are equal, which is probably a reasonable assumption since it has access to the international capital market, the problems of how much of the mineral to extract and what to do with the proceeds can be analysed separately. The rate of extraction can be chosen so as to maximize the net present value of the resource stock and the returns from the industry can be invested or consumed depending upon the province's preferences. Investments can be made within the province, within Canada or abroad such that the marginal rates of return in all areas and activities are equalized. In this way the resource capital is gradually depleted and consumed or transformed into an alternative form of capital.

With some important exceptions the provisions under which the Alberta and Saskatchewan heritage funds operate are designed to follow the prescriptions

of the model of economic welfare maximization. Rates of mineral extraction are determined by market forces except in so far as identifiable market failures in the form of externalities of various kinds dictate corrections, generally in the direction of lower extraction rates. Nonrenewable resource revenues are collected by means of a set of taxes which, in the case of Saskatchewan uranium and, as argued in section 2 of this study, succeed in collecting a substantial portion of mineral rent and in altering the private sector choice of extraction rates in the appropriate direction. The tax revenues are paid into a heritage fund of which a portion is consumed and a portion invested.

At this point reality diverges significantly from the theoretical ideal. It has already been argued that consumption of resource rents in the form of publicly produced goods and services results in rent dissipation through fiscally induced migration. In choosing a programme of investment, for the benefit of future generations, the Saskatchewan Heritage Fund, unlike the Alberta fund, restricts itself to investments within the province. This restriction is likely to lead to some portion of the funds invested earning a lower return than the opportunity cost rate as given by the international capital market. The policy of investing resource revenues internally will, therefore, inflict costs on future generations.

It is arguable that the notion of exhaustibility is not an appropriate one to use in an analysis of public policy towards the extraction of one mineral. Within any reasonable time frame it appears as if Saskatchewan's natural resources are inexhaustible: as oil reserves are depleted uranium reserves increase and the value added by the mineral industry may rise. There is a substantial likelihood that further resource discoveries will replace depleted

uranium reserves in the provincial economy. Adopting this view would have little impact on extraction policy since the scarcity rent is likely to be small in relation to the Ricardian and monopoly rents derived from uranium mining. It might, however, have a substantial impact on the manner in which resource revenues are used. If resource exhaustion were not seen as an important issue the proportion of resource revenues invested for the benefit of future residents of the province might well be lower.

1. (v) Government Policy Towards a Resources Boom

One policy which a provincial government could adopt towards a resources boom is to have no policy. In other words, the private market system could be left to allocate factors of production and distribute rents. The outcome of this approach has been described in subsection (ii). There seem to be two sets of reasons why this approach is not followed: in the first place, there are efficiency and equity arguments which put pressure on provincial governments to collect resource rents; and, secondly, these governments have various policy goals which they believe can be furthered by expenditures of mineral revenues.

The efficiency argument for collecting resource rent from the uranium industry can be judged weak for two reasons. First, the uranium reserves are not an open-access resource in the sense that an unregulated fishery or oilfield is. It is possible that in the absence of resource rent taxation there would be some premature exploration aimed at capturing rights to deposits but the amount of rent dissipation would probably be slight. Secondly, there is evidence of a lack of overriding concern for rent dissipation in the manner in which provincial governments choose to dispose of resource revenues. It is seen as politically infeasible or undesirable to "privatize" the heritage funds, as suggested by McMillan and Norrie (1980), and so programmes of expenditure are undertaken which result in a fiscal dissipation of rent.

The equity argument for the collection of resource rent is, as was argued earlier, persuasive: it is necessary from a political standpoint that the provincial government, acting for the province, be seen to receive a fair or reasonable return from the depletion of nonrenewable resources. Once

substantial flows of resource revenue are accruing to the treasury there are two sets of reasons for rent dissipation. First, there is the fundamental inability, cited by Usher (1981), of the legislature to assign shares in resource rent directly to members of society. The politically feasible way of disposing of resource revenues is to undertake expenditures which result in much of the rent being dissipated and in a small amount of it accruing in an indirect fashion to politically influential groups such as urban land holders. Secondly, the expenditures which dissipate rent may help towards achieving various goals which the government has for the provincial economy.

The provincial policy goals identified by Norrie and Percy (1982) are extensive growth and industrial diversification. Extensive growth is seen as a way of increasing the province's influence in the confederation and of taking advantage of agglomeration economies. Industrial diversification is regarded as an insurance against fluctuations in the highly variable primary product markets. Whether or not provincial policies contribute to these goals can be tested by means of the booming sector models described in subsection (ii). The model can be constructed with and without the so called "province building" policies and the contribution of these policies to provincial goals can be assessed. This is approach taken by Norrie and Percy (1982) and the remainder of this subsection reviews their model and results.

The Norrie and Percy model is an expanded version of the booming sector model described earlier. It has six sectors: a nonrenewable resources section (1), which is the booming sector (B); renewable resource, resource processing, and secondary manufacturing sectors (2-4), which corresponding to the lagging sectors (L); and service and government sectors, (5 and 6), producing

nontradeables (N). The advantage of a six sector model is that it will give much more detailed prediction than the three sector booming sector model. Its disadvantage is that it requires a numerical solution and its results may be sensitive to functional forms and parameter values chosen. In the Norrie and Percy formulation labour is mobile among the six sectors and capital is sector specific. They present three sets of solutions: a short-run equilibrium in which there is no in- or out-migration of factors, and no regional balance of payments; a long-run equilibrium in which factor migration in response to changes in factor prices occurs but regional trade accounts are not required to balance; and a long-run in which regional trade accounts are balanced by factor and product price changes and factor movements.

The methods of analysis is first to establish a base case. The effects of a small increase in the price of the nonrenewable resource on the solution values of the model are calculated on the assumption that there are no taxes on resource income. In this model government expenditure is financed entirely by a per capita levy on residents. The predictions of the model are in accord with the standard booming sector model: growth occurs disproportionately in sectors 1 and 5 and 6 which correspond to sectors B and N in the simple model. The results of the base case model are used for purposes of comparison with the solution to a model in which taxes on the returns to resources and capital are used to pay for government produced goods. This means that the per capita levy needed to finance a given output of government goods is lowered below the cost of producing these goods as in the fiscally induced migration model.

The results of the analysis are that, as compared with the base case, the policy of using resource revenues to subsidize the production of government

goods and services does result in more extensive growth, defined as the percentage increase in gross domestic provincial product (GDPP). The main reason for this is the fiscally induced inmigration of labour. There is, however, a lower rate of intensive growth, defined as the percentage increase in real GDPP per capita evaluated at its opportunity cost. The reasons for the result are the greater inmigration of labour because of the subsidy of government output, and the efficiency cost of the subsidy. The effect of the "province building" policy on industrial diversification is harder to guage. Considering the long-run in which the region's trade is in balance, the economy is less diversified than before the resources boom: the proportion of GDPP accounted for by the resource processing and manufacturing industries has fallen. On the other hand, the "province building" policy results in a slightly more diversified economy than occurs in the base case in which no attempt is made to tax incomes derived from the resources boom. In this sense, the provincial policies do make a slight contribution to industrial diversification. Finally, the model confirms the view that the "province building" policy results in rent dissipation since it lowers the real per capita income gain conferred by the resources boom. An exception to this conclusion is the case in which the efficiency gains from agglomeration economies are large enough to outweigh the efficiency costs of factor misallocation through the subsidization of public sector output.

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2. Collecting Mineral Rent

2. (i) Introduction

This section analyses the effects of various methods of collecting mineral rent. There are two important sets of issues to be examined; one relating to the efficiency, and the other to the effectiveness of the various schemes. While in principle the appropriation of economic rent by the government sector should cause no change in private sector behaviour, it is often difficult in practice to design a collection system which applies only to pure rent and at the same time has reasonable costs of administration and collects a reasonable proportion of the rent generated in the private sector. To the extent that the collection scheme appropriates income other than pure rent an incentive will be created for changes in private sector behaviour. In the case of mining firms these are changes in the choice of extraction rate, extraction technique, and cut-off grade which, while they may maximize the net of tax present value of the deposit to the private firm, may lower its gross of tax present value to the economy as a whole as compared with the firm's behaviour in the absence of a tax or similar rent collecting device. This reduction in present value is the efficiency cost of a non-neutral rent collecting scheme. Against efficiency cost, of course, must be set the effectiveness of the scheme which can be thought of as the proportion of economic rent it succeeds in appropriating. The choice of a system of rent collection usually involves a trade-off between the two goals of efficiency and effectiveness.

In subsection (ii) a brief survey of the effects of various mineral

taxes on the behaviour of mining firms as predicted by economic theory is presented. While these various taxes are analysed separately it is often the case that revenue is collected from the mining industry by a combination of measures. Subsection (iii) considers the taxes which will be levied on the uranium mining industry in Saskatchewan and predicts the effect of each on the rate of extraction of the mineral. Since some taxes are predicted to increase the rate of extraction and others to lower it the net effect cannot be guaged from a qualitative model. In subsection (iv) a quantitative model is used to analyse the net effect of the various tax measures on the privately optimal rate of extraction for the Key Lake mine which will dominate the Saskatchewan uranium industry in the 1980's. This model, which was presented in a paper by Campbell and Wrean (forthcoming), indicates that the tax regime faced by the uranium industry will cause firms to adopt lower rates of mineral extraction, but that the cost of this distortion will be relatively low while the taxes will collect a relatively large share of economic rent.

2. (ii) The Effects of Mineral Taxation: a brief survey

In this discussion mineral taxation will be interpreted widely so as to include any measure aimed at capturing mineral rent. On this interpretation the outright sale or leasing of mineral resources will be covered as well as the major tax measures which have been proposed and used (for a review see Department of Mines and Energy, Darwin, 1981). These include: a mineral licence, which is an annual charge or lease payment for the use of the resource; a property tax which is an annual charge assessed at some percentage of the value of the mineral property; a severence tax which is a royalty assessed either as a payment per unit of output or as a percentage of the value of each unit of output; a profits tax which if it is to be interpreted as a method of collecting mineral rent must be levied at a higher rate on the mining industry than on industry in general; and a rate of return tax which is a flat rate or graduated tax on profits above an allowable rate of return and which is referred to as a resource rent tax (Garnaut and Ross, 1975). In any given jurisdiction a combination of these measures is normally to be found and the way in which they interact in terms of the deductibility or nondeductibility of one set of tax payments against another tax base varies from jurisdiction to jurisdiction. In the present analysis the effects of each tax measure will be assessed on an individual basis.

All of the rent capturing devices mentioned above are currently in use in some jurisdictions. Conditional rights to oil and gas in the provinces of Alberta and Saskatchewan in Canada and in the U.S. outer continental shelf are allocated to the private sector by direct sale. Many jurisdictions require that mining operations be licensed although the level of license fee usually suggests that the object of the licensing system is one of regulating activities rather than collecting

rent. A property tax levied on mines is a common source of local government revenue in the U.S. (Scott, 1973, 194-211). Severance taxes on mineral resources are almost universal: Australian examples are Western Australia's unit royalty of 2.5 cents per tonne of black coal mined, and South Australia's ad valorem royalty of 2.5% of the value of coal produced (Emerson and Lloyd, 1981); it can be argued that severance taxes can take indirect forms such as excess freight charges on mineral products carried by government owned railways. While mining companies are subject to profits tax almost universally, it is unusual to find mineral rent collected by means of a surcharge on the rate of corporation income tax paid by mining companies. The rate of return tax is currently used in a number of jurisdictions including South Africa, Papua New Guinea, Zambia and the provinces of Saskatchewan and Manitoba in Canada (White, 1978).

Before examining the effects of the various taxes on the production plans of mining companies some consideration will be given to the effects of sales of mineral leases as a rent capturing device. In the absence of mineral taxes auctioning mineral leases in a perfectly competitive market will result in the capture of all mineral rent. While much of the literature (Reece, 1979) on this method of collecting rent deals with designing bidding systems which will overcome imperfections in the market for mineral leases, empirical evidence (Mead, 1977) suggests that, at least in the case of U.S. outer continental shelf oil resources, competition has been effective in enabling the government to capture a high proportion of economic rent. When the auctioned mineral property is subject to some form of mineral tax if developed the private sector bids will obviously be correspondingly lower. Mineral rent is then collected as a lump-sum initial payment and a stream of tax revenues conditional on the value of the deposit. It

has been argued (Leland, 1978) that this two-part method of collecting resource rent can lead to optimal sharing of risk between the government and the private sector. In view of the advantage of a two-part system in promoting economic efficiency it seems likely that such a system will become increasingly used and it should be borne in mind that the various tax instruments analysed in the following pages will probably be applied to deposits for which firms have already made initial payments.

When analysing the effects of mining taxes it is helpful to treat the effects on extraction and exploration separately. The model commonly used to assess the effects of taxes on extraction plans is that of Hotelling (1931). Hotelling's model is an industry model and it has been criticized (Campbell, 1980) when used to derive predictions about the behaviour of individual firms. Nonetheless the qualitative conclusions of Hotelling's industry model with respect to rates of extraction also hold in an appropriate model of the mining firm and because of its convenience and familiarity it will be used in this survey. In Hotelling's model the mine operator chooses an extraction plan, $q(t)$, and a mine life, T, that maximizes the present value of profit obtained from the mine. The characteristics of the solution to this problem are: marginal profit $(\partial\Pi/\partial q)$, which can be interpreted as the value of an additional unit of mineral reserves, rises over the mine's life at a rate equal to the interest rate; at time T average profit reaches its maximum and reserves are exhausted.

When the impacts of the various mining tax measures described earlier are analysed (Scott, 1973, Burness, 1976, Helliwell and Heaps, forthcoming) using Hotelling's model the following effects on extraction plans can be predicted: a

mineral licence which acts as an annual carrying charge on the mine creates an incentive to deplete the mineral stock more quickly and results in higher rates of extraction and a shorter mine life; a property tax which is a carrying charge assessed as a percentage of the value of the mineral stock also creates an incentive to deplete faster thereby shortening the life of the mine; a severance tax or royalty levied at a constant rate on a unit or ad valorem basis shifts the marginal profit function downwards thereby lowering extraction rates and lengthening the mine's life; if the rate of severance tax is known to rise at a rate equal to the rate of interest then the incentive to postpone tax payments is removed and a severance tax of this kind is neutral with respect to the firm's extraction plans; a profits tax in the absence of a depletion allowance is neutral with respect to extraction plans since maximizing the present value of after-tax profits also maximizes before-tax profits; a depletion allowance is in effect a payment to the firm for each unit of the mineral stock extracted and is thus equivalent to a negative severance tax or severance subsidy which creates an incentive to deplete the resource more quickly; finally, a rate-of-return tax is a flat-rate or graduated profit tax which is neutral under the conditions of production assumed in Hotelling's model; it will be argued later that under more realistic assumptions about production the rate of return tax may alter extraction plans.

Hotelling's model is also used by Helliwell and Heaps to analyse the effects of the various tax measures on the level of exploration effort undertaken by firms. The solution to the model involves marginal profit, or the marginal value of reserves, being equated to a shadow-price which rises over time at the rate of interest. Helliwell and Heaps argue that mineral exploration will be carried to

point at whichmarginal finding costs equal the shadow-price. There are two principal criticisms of this approach: in the first place, a deterministic model of mineral exploration is rather unsatisfactory and it has been shown (Devarajan and Fisher, 1982) that with a stochastic mineral reserves production function the equality between marginal finding costs and marginal value of reserves need no longer hold; secondly, models of exploration which equate marginal value of reserves found with marginal finding costs have been criticized (Campbell and Lindner, 1983) for disregarding the value of information resulting from exploration effort. Despite these criticisms the following analysis will be based on the proposition that any tax measure which reduces (raises) the shadow-price of mineral reserves reduces (raises) the volume of exploration resulting in smaller (larger) additions to reserves, lower (higher) extraction rates, and shorter (longer) mine lives.

The effects of the various tax measures on the shadow-price of reserves are as follows: a license fee reduces the shadow-price of reserves and discourages exploration; a property tax can be thought of as an ad valorem licence fee which discourages exploration; a severance tax, whether levied at a constant rate or at a rate increasing at the rate of interest, lowers the shadow-price of reserves and discourages exploration. The effect of the profits tax in the Hotelling model is to lower the shadow-price of reserves in the same proportion as the rate of tax. If exploration costs are expensed and fully deducted against taxable income the lower shadow-price or marginal value of reserves is offset by lower marginal costs to the firm of exploration and the profits tax is neutral with respect to exploration effort. In a model which takes account of the value of information yielded by exploration Campbell and Lindner (1983) have shown that this latter result is valid only if firms are risk neutral. If the profits tax is accompanied by a depletion

allowance the implicit subsidy on extraction will counter to some extend the lowering of the shadow-price of reserves caused by the tax: a 100% depletion allowance would completely offset the effect of the profits tax on the shadow-price thereby rendering the profits tax neutral with respect to exploration effort but of course such a tax regime would yield no revenue. The rate-of-return tax is a profits tax which will be neutral with respect to exploration effort according to the Hotelling model provided that exploration costs are fully deducted against taxable income. Garnaut and Ross (1979) have emphasized that deductibility of all costs is a cricial feature of their resource rent tax proposal which is a type of rate-of-return tax. As in the case of the profits tax the neutrality of the resource rent tax with respect to exploration effort has been shown (Campbell and Lindner, 1983) to hold only in the case of risk neutrality on the part of mining firms. In summary, any mining tax tends to lower the marginal value of reserves to firms and, in a deterministic model, to lower exploration effort unless this tendency is corrected by some form of subsidy on exploration costs.

The Resource Rent Tax (RRT) is a form of rate-of-return tax proposed by Garnaut and Ross (1975). It taxes at a flat or graduated rate profits in excess of an allowable rate of return on invested capital. It was noted earlier that the RRT is currently in use in a number of jurisdictions. The Hotelling model predicts that the RRT will be neutral and this conclusion is reinforced by a paper by Mayo (1979). The neutrality of the RRT, however, rests on three critical assumptions: full deductibility of costs, an allowable rate of return equal to the firm's cost of capital, and risk neutrality. The importance of the first of these assumptions has already become apparent in the present discussion and is stressed by Garnaut and Ross (1979). The importance of the second assumption is also emphasized by Garnaut

and Ross (1979) and the effect of an RRT scheme in which the allowable rate of return exceeds the firm's cost of capital is analysed by Olewiler (1979). Olewiler's analysis is based on a model of extraction in which capital and labour are used in variable proportions. Setting the allowable rate of return higher than the cost of capital subsidizes the use of capital by the firm and results in an inefficient allocation of capital between mining and other activities. The third of these assumptions is developed by Campbell and Lindner (1983) in a model which analyses the value of information resulting from exploration. The conclusion which results from the various papers cited here is that for a risk averse firm engaging in exploration and using capital and other factors of production to extract ore there is one particular value of the resource rent tax which will not affect exploration effort, and that tax will be neutral with respect to factor proportions and extraction rate provided that the allowable rate-of-return is equal to the firm's cost of capital. Full deductibility of extraction costs is necessary for this conclusion but the rate of RRT can be adjusted to be neutral with respect to exploration depending on whether or not exploration costs are deductible (Campbell and Lindner, 1983). While neutrality is a desirable property of a mineral tax system it is unlikely that the tax rate would be chosen to achieve neutrality independent of considerations of tax revenue.

2. (iii) Neutrality of the Saskatchewan Uranium Royalty (SUR)

The SUR has been described by Anderson and Barnett (1983) and by Kwon (1983). It consists of a basic royalty (SBR) which is an ad valorem tax on the value of production, and a graduated royalty (SGR) which is a graduated rate of return tax. In addition to the SUR uranium mining companies operating in Saskatchewan will be subject to the standard federal and provincial corporation income taxes.

Using the economic theory of the mine described above it is possible to make some predictions about the effect of each component of the tax regime facing Saskatchewan's uranium producers. For example, it is recognized in the mineral economics literature (see Helliwell and Heaps [forthcoming]) that the effect of ths SBR will be to create an incentive for the firm to reduce its planned rate of extraction. Since the royalty can be regarded as an addition to unit cost its imposition may result in some already relatively high cost portions of the ore deposit being abandoned. Whether a lower rate of extraction of a smaller economically recoverable mineral deposit results in a longer or shorter mine life depends upon the individual circumstances. In lowering its planned rate of extraction the firm may alter factor proportions so that the mining operation becomes less or more capital intensive. Again the individual circumstances of production will determine the direction of change. Finally since the imposition of a basic royalty reduces the value of the mineral deposit to the producer the royalty will tend to discourage exploration unless there is some offsetting measure to reduce firms' exploration costs.

The economic theory of the mine has been used to analyse the effects of

rate of return taxes in general (Olewiler [1978]), and of the (SGR) in particular (Kwon [1983]). Both these writers concede that a rate of return tax which is neutral with respect to the mining firm's extraction plan can in theory be designed. In practice, however, most schemes which have been used (see White [1978]) have fallen short of this theoretical ideal. In order to identify the shortcomings of the SGR it is helpful to consider first the structure of a tax which is truly neutral with respect to the extraction plan.

The basic principle underlying a neutral rate of return tax is that all costs incurred in undertaking a project can be deducted against taxable income. This principle can be satisfied by not levying the tax until all production costs have been recovered. This can be accomplished by taxing operating profit once preproduction expenses have been recouped. Preproduction expenses can be compounded forward from the time at which they are incurred to a time at which the project starts to yield an operating profit. From this time the unrecovered capital cost of the project continues to be increased annually by an interest factor but it is also decreased annually by the value of operating profit. Once the value of unrecovered capital cost falls to zero there is no capital cost eligible as a deduction against operating profit for tax purposes. Operating profit, defined as gross revenue less production cost where production cost excludes depreciation and depletion allowances, is then subject to tax at a flat or graduated rate.

Before comparing the underlying principle of this tax with the SGR it should be noted that Campbell and Lindner (1983) have argued that even if a rate of return tax does not affect planned rates of extraction it may not be

truly neutral in that it may affect the amount of exploration which will be conducted on a deposit thereby altering the probability of it being extracted. Thus the "neutral" rate of return tax is likely to be neutral only with respect to those projects which will be undertaken despite the tax regime. Campbel and Lindner show that tax neutrality with respect to all deposits is achieved only if mining firms are risk neutral and if all expenses including exploration costs are deductible from taxable income.

The SGR scheme departs from the basic principle of deductibility of costs in several ways. In the first place, it attempts to isolate each mining project for tax purposes so that only costs associated with a given project can be deducted against income from the project. This means that expenditures on unsuccessful exploration and extraction ventures may not be deductible and this violates a condition for tax neutrality.

Secondly, there is no guarantee that preproduction expenses will be compounded forward at an effective rate of interest equal to the firms's required rate of return on capital invested in the project. All uranium mining firms are required to use an interest rate equal to 110% of the average prime lending rate for compounding costs forward irrespective of their debt/equity ratios and costs of debt and equity capital. Furthermore, as pointed out by Kwon (1983), the procedure originally prescribed by the SGR for compounding preproduction expenses forward may yield a level of capital investment at the start of production which is actually less than the cumulative value of these expenses compounded at the prescribed rate of interest.

Thirdly, in addition to providing for the recovery of capital cost through the deduction of preproduction expenses against taxable profits the SGR allows firms to earn annually an additional 15% of the estimated capital cost at the start of production before they enter a rate of return bracket which is subject to tax. Since the 15% threshold rate is based on the uninflated estimate of capital cost at the start of production the significance of this concession declines in real terms over time. Nevertheless the provision for a successful venture to deduct more than its initial capital cost violates the principle underlying the neutral rate of return tax.

The net effect of these three deviations from the structure of a neutral rate of return tax cannot be predicted on the basis of an abstract economic model. The levying of the tax on a project basis and the possibility that the effective rate of return allowed on capital is lower than the firm's required rate are likely to discourage marginal ventures. On the other hand the failure to tax returns below the threshold rate will tend to encourage larger capital expenditures on projects which do go ahead.

In addition to the SUR the uranium mining firms operating in Saskatchewan will be subject to corporate income tax. An income or profits tax in the absence of a depletion allowance, is neutral in the same limited sense as the rate of return tax since it provides for the deductibility of all project costs. A depletion allowance, however, acts as a negative severance tax and this tends to encourage a faster rate of extraction than in the absence of the tax.

In the following subsection the combined effect of the SUR and the corporate income tax on the extraction plans for a uranium deposit will be

assessed by means of a numerical model. The model considers a uranium deposit which has already been explored and which will be extracted under the Saskatchewan tax regime. Thus the model provides no information about the effect of the tax system on the likelihood of a deposit being mined. It simply indicates whether the net effect of mineral taxation is to raise or lower the planned extraction rate.

2 (iv) Efficiency, Effectiveness and the Extraction Plan for the Key Lake Mine

In this section of the paper a model of the Key Lake Mine is used to determine whether the tax regime within which Saskatchewan uranium mines operate has the property of neutrality. Because of the nature of the model, which is described below, it is not possible to determine if the tax system causes firms to alter factor proportions or to change exploration plans. The model's finding are confined to the effect of the tax system on the optimal extraction rate. Briefly the results are that the tax system results in a fairly wide divergence between privately optimal rates of extraction with and without the tax system but that these divergencies have a relatively low economic cost.

The mining model which is used to examine the effect of the tax system is described in a paper by Campbell and Scott (1980) which analyses a series of Australian uranium mines. The mining cost functions used in the Australian study were of the form $K = Cx^{\alpha}$ where K is cost, C is an intercept term, x is the rate of milling, and α is a scale parameter. In the present study the scale parameters of the Australian study have been retained and the intercept terms have been altered to reflect cost conditions in Saskatchewan. The method of alteration was as follows: estimates of the various mining and milling costs and labour requirements associated with the planned milling rate of 725 t.p.d. for the Key Lake project were obtained from InterGroup Consulting Economists Ltd (1980); the intercept terms for the present study were obtained by setting K equal to the value estimated from the InterGroup data, setting $x = 725$, maintaining the α value used in the Australian study and solving for C. The information used about the Key Lake uranium deposit was that reported in a study of a series of Saskatchewan uranium mines by Campbell and Wrean (forthcoming). The mining model together with the

cost functions and the pit data constitute the "Proxy Key Lake Mine (PKL)" which is used to examine the extent and cost of any element of nonneutrality introduced by the tax system.

The PKL in the present paper differs considerably from that of Anderson and Barnett (1983). Their model estimates the net present value of the mine under the federal and provincial tax regime when the milling rate is approximately 725 t.p.d. as planned. This allows them to calculate the revenue shares reported in their paper. The present study obtains a series of milling rates as solutions of the model. For various assumptions about price the milling rates which maximize net present value gross of tax (social value) and net present value net of tax (private value) can be calculated. It can be argued that the latter will be the milling rate chosen by the private firm and that the divergence between it and the former rate is a distortion introduced by the tax system.

In order to maintain comparability as far as possible with the Anderson and Barnett paper the present study incorporates their basic assumptions: the real discount rate is set at 10% and the interest factor used to gross up the Capital Investment Base is set at 6%. Nonetheless it appears that the capital cost and operating cost estimates of the present study are slightly lower than those of Anderson and Barnett: the present study estimates a value at a milling rate of 725 t.p.d. and a uranium price of US$30 per lb U_3O_8 of $1,319 million (1979 Can. $) where as the Anderson and Barnett figure is $1,089 million (1981 Can. $). A further point is that the privately optimal milling rate at a US$30 per lb price is calculated in the present model to be 850 t.p.d. which is somewhat higher than the planned rate of 725 t.p.d. Despite these differences

the two models are broadly comparable and the estimates presented below of distortions resulting from the tax system can be regarded as complementing the Anderson and Barnett estimates of the distribution of economic rent.

Following Bradley, Helliwell and Livernois (1981) indices of tax system efficiency and tax share of potential resource value will be used to summarize the performance of the tax system. Tax system efficiency is calculated as follows: for each price of uranium under consideration the mining model is used to calculate the privately optimal milling rate given the tax system and the privately optimal rate with no taxes which, in the absence of external effects and considerations of income distribution, can be regarded as the social optimum; the ratio of net present value of returns to all parties at the privately optimal milling rate to net present value at the socially optimal rate is then a measure of the proportion of potential resource value which is actually realized and as such is a measure of tax system efficiency. The tax share of potential resource value is simply the ratio of present value of tax collections by the federal and provincial governments at the privately optimal milling rate to the project's net present value at the socially optimal rate and as such is a measure of the share of potential resource value captured by the public sector. In interpreting the results it should be noted that the tax revenues include all federal and provincial revenues and not solely the revenues from the SUR, although the latter are a substantial proportion of total revenue, and exclude the returns to the Saskatchewan Mining Development Corporation (SMDC) which is a Crown Corporation owning 50% of the equity in the Key Lake project.

The estimates of optimal extraction rates and net present values obtained from the model for the range of prices considered by Anderson and Barnett and for

inflation rates of 0% and 10% are reported in Table 1. Tax system efficiency (E) is given for each price as the ratio of column (4) to column (3), while tax share of potential resource value (S) is given by unity less the ratio of column (5) to column (3). The tax efficiency and tax share estimates are reported in Table 2.

It can be seen from Table 1 that the effect of the tax system is to make the privately optimal extraction rate considerably lower than the socially optimal rate. For example, at a price of US$30 the privately optimal rate is only 60% of the socially optimal rate. Since the PKL deposit is fully extracted in both the no-tax and tax scenarios this means that the life of the mine is extended by 60% as a result of the tax system. While the privately optimal extraction rate is considerably lower than the socially optimal rate as a result of the tax system, it can be seen from Table 2 that there is a very low economic cost associated with this distortion: at a price of US$30 per lb, for example, the cost of the distortion introduced by the tax system is $58 million or 3% of net present value. The reason for this relatively low cost is that the function relating net present value to extraction rate is very flat around its maximum point. As Bradley (forthcoming) points out, this is a common feature of mining models described in the economics literature. Table 2 indicates that the tax system is effective in capturing a considerable proportion of economic rent. The tax share in the no-inflation case ranges from 45-65% and in the 10% inflation case from 56-67%. The reason for the higher tax shares in the latter case is the feature of the SGR referred to earlier that the rate of return for tax purposes is calculated on the basis of the estimate of capital cost at the start of production with no provision for subsequently adjusting this cost figure for inflation. The tax

shares reported in Table 2 are not directly comparable with Anderson and Barnett's estimate that 75-80% of economic rent is captured by government. Since the SMDC owns 50% of the equity in the Key Lake Project total government share includes 50% of the private net present value estimates reported in column (5). When this adjustment is made it can be calculated that at a price of US$30 per lb the total government share is 80% in the no-inflation case and 82% when 10% inflation is assumed.

It was implied in subsection (i) that the privately optimal rate of extraction in the absence of taxes could be equated with the socially optimal rate. This assumes that any external and income distribution effects of the mine can be disregarded. In fact the provisions made for health and environmental protection and regional economic development in the Saskatchewan Government Response to the Key Lake Board of Inquiry Report suggest that policy makers are anxious to limit harmful external effects and to ensure that some of the benefits of the Key Lake project accrue to local residents. It has been suggested by Scott and Campbell (1979) that objectives such as these may be served by a policy of attenuation. This policy involves reducing the impact of the mining industry at each point in time and extending its life. One way of achieving this objective is to encourage individual mines to operate at relatively low rates of extraction. It can be seen from Table 1 that this is one effect of the tax regime within which the uranium mines in northern Saskatchewan operate. On the basis of Tables 1 and 2, therefore, it appears that the SUR is a relatively low cost means of collecting a significant proportion of the economic rent from uranium mining and at the same time contributing to the objectives of environmental protection and regional economic development.

Table 1: Extraction Rates and NET Present Values for the PKL

Inflation Rate	Extraction Rate (t.p.d.) (1) Social Optimum 0%	(1) Social Optimum 10%	(2) Private Optimum 0%	(2) Private Optimum 10%	Total NPV (millions 1979 Can $) (3) At Rate(1)	(4) At Rate(2) 0%	(4) At Rate(2) 10%	Private NPV (Milli 1979 Can $) (5) At Rate (2) 0%	(5) At Rate (2) 10%
Price US$ per lb.									
15	675	675	475	500	576	551	558	316	255
20	850	850	650	675	957	932	938	443	385
25	1,075	1,075	825	725	1,365	1,346	1,319	587	525
30	1,425	1,425	850	850	1,805	1,747	1,747	722	658
35	1,700	1,700	1,025	925	2,267	2,200	2.170	858	793
40	1,725	1,725	1,100	1,075	2,738	2,645	2,638	1,001	936
50	2,100	2,100	1,425	1,450	3,690	3,622	3,628	1,309	1,242
60	2.k50	2,150	1,550	1,500	4,667	4,374	4,558	1,618	1,551

Table 2: Tax Efficiency and Tax Share for the PKL

	No Inflation		10% Inflation	
Price	Efficiency (E)	Tax Share (S)	Efficiency (E)	Tax Share (S)
18	.96	.45	.97	.56
24	.97	.54	.98	.60
30	.97	.57	.97	.62
36	.97	.60	.97	.64
42	.97	.62	.96	.65
48	.97	.63	.96	.66
60	.98	.65	.98	.66
72	.98	.65	.98	.67

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3. The Economic Impact of Uranium Mining in Saskatchewan

3 (i) Introduction

This section presents a forecast of Saskatchewan's uranium production and an estimate of the impact of the industry on gross domestic provincial product and employment. A survey of Canada's uranium reserves indicates that Saskatchewan is likely to have the bulk of the nation's low cost resources. While availability of reserves is unlikely to be a factor limiting output in the near future there are some aspects of federal and provincial government policy which will tend to restrict the size of the industry. In particular, the federal concern to ensure adequate domestic supplies and to restrict the uses of Canadian uranium to peaceful purposes, and the provincial government's desire for sustainable economic development in northern Saskatchewan will limit the growth of the industry. A policy which is shared by both federal and provincial governments is that of attempting to maintain uranium prices and this will tend to restrict Canadian exports. Given these policy objectives and the state of the world uranium market a relatively modest forecast of Saskatchewan's uranium production seems to be justified. This forecast is used as the basis of a set of estimates of the contribution of the uranium mining industry to economic growth in Saskatchewan. Since the forecast is extremely speculative the estimates of the impact of the uranium mining industry should be regarded as illustrative in nature.

3 (ii) Reserves

The two principal regions in which Canada' uranium reserves are located are the Elliot Lake region of Ontario (about 60% of reserves in 1980) and the extreme north of Saskatchewan (about 31%). Saskatchewan's share of both reserves and production (about 34% in 1980) is likely to rise significantly in the next two decades because of the relatively low cost nature of the province's uranium resources. In 1980 60% of Canada's uranium exploration expenditures were incurred in Saskatchewan, reflecting the industry's belief that substantial additions to reserves which are mineable at low cost will be made in that province. Some of the recently discovered deposits in Saskatchewan are already in or about to start production using low-cost open-pit mining techniques and the entry of these mines to the industry will raise the province's share of Canadian production to over 50% by the mid-1980's. It seems safe to conclude that Saskatchewan's uranium mining industry will become an increasing proportion of the Canadian industry over the next quarter century.

Factors of importance in determining the development costs of a uranium mine are the grade and configuration of the deposit and the depth at which it occurs. For depths up to 500 feet relatively low-cost open-pit mining techniques can be used whereas deposits at greater depths require more expensive underground mining as in the Elliot Lake region. Thus Rio Algom's and Dennison's production costs at Elliot Lake are estimated to be $54 and $60/kg U respectively in 1979 whereas the cost of production at Key Lake will be under $30/kg U in 1979 dollars. Despite the higher costs of production in Ontario the federal government has indicated that it wishes to maintain the industry in the Elliot Lake region. Furthermore the two remaining producers have the bulk of their production committed in contracts with Ontario Hydro until the second decade of the 21st century.

Within Saskatchewan there are two main uranium bearing areas. The Beaverlodge District north of Lake Athabasca has had several uranium mines, the last of

which was operated by Eldorado Nuclear Limited and was closed in mid-1982. The Athabasca Sandstone Basin south of and underlying Lake Athabasca contains substantial uranium reserves. The deposits associated with the Athabasca Basin are generally located at the point of contact of the sandstone with the Precambrian basement. Initial exploration of the Basin focussed on its margins where the contact between the formation and the basement is close to the surface. This resulted in the discovery of several open-pit mining prospects such as Cluff Lake, Key Lake, Rabbit Lake, and the Collins Bay deposits. The geology of the Athabasca Basin and the history of its exploration is very similar to the Alligator Rivers area in the Northern Territory of Australia where open-pit prospects such as the Ranger deposits have been located. Subsequent exploration of the interior of the Athabasca Basin has resulted in the discovery of deposits such as Midwest Lake, Dawn Lake and Waterbury Lake which lie at depths of over 500 feet at the contact between the floor of the Basin and the basement rock.

Estimated uranium reserves at the Cluff Lake, Rabbit Lake - Collins Bay, and Key Lake mines are around 130,000 metric tons of uranium which is almost 20 years' supply at planned production rates. The Cluff Lake 'D' and Rabbit Lake deposits are already exhausted. Additional sales could be met from one of around 10 other deposits which are at an advanced state of exploratory and pre-development work. These deposits tend to form a queue for the opportunity to extract, the places in the queue mainly reflecting production costs. As new discoveries are made and investigated the order of the deposits in the queue changes in accordance with the economic principle that low-cost deposits will be exploited first; thus the relatively shallow McLean Lake deposit has probably overtaken the deeper Midwest Lake deposit for which a preliminary environmental impact statement had been filed prior to the recent softening of the uranium market but which

has now been deferred at least 5 years. The weak uranium market together with the province's substantial reserves have led to a decline in uranium exploration expenditures in Saskatchewan from $77 million in 1980 to around $40 million in 1982.

To conclude this section it is unlikely that availability of reserves will limit Saskatchewan's uranium production in the foreseeable future. Indeed the prospects for continued supplies of low-cost uranium are such that Saskatchewan is likely to supply the bulk of any increases in Canada's uranium output over the next twenty years. Ontario's output is unlikely to rise significantly above the 5000 - 6000 tonnes U range and given the low levels of exploration expenditures there is little prospect of an increase in mineable reserves at forecast prices. As the following statistics on the distribution of uranium exploration expenditures in 1980 show, it is only in the NWT that significant additions to reserves are likely and development there is likely to be delayed by unsettled native land claims:

Table 3.1: Uranium Exploration Expenditures by Province (1980) (%)

Sask	NWT	Quebec	NS	Nfld	Ont	NB	Yuk	Man	Alta	BC
60	23	5	4	3	1	1	1	1	1	-

(Source: Uranium in Canada: 1980 Assessment of Supply and Requirements)

Thus it seems likely that Canada's uranium industry will be increasingly dominated by Saskatchewan for the rest of the century.

3 (iii) Restrictions on Development Imposed by Government Policy

There is a range of goals of government policy which would be served by restricting uranium output to a level below that which would appear to be justified by market demand and the availability of reserves. One objective is to maintain or raise the price of uranium and this is discussed in the following subsection dealing with the uranium cartel. In the present subsection various objectives of federal and provincial policy are discussed which are likely to result in limitation on output.

There are a number of general objectives of Canadian mineral policy which are common to all minerals: to ensure adequate domestic supplies; to accumulate information on reserves; to realize opportunities for further processing; to increase the return to Canadians from exportable surpluses; and to contribute to orderly world mineral development and marketing. In the case of the uranium industry an additional objective of national policy is that exports be used for peaceful purposes only. Federal policy on uranium is implemented by the Uranium Export Review Panel which may recommend that the Minister withold approval of uranium export contracts.

The objectives of increasing the return to Canadians and contributing to "orderly" marketing are advanced by witholding supplies in concert with other major producers. A further dimension of this policy is the need to ensure that, given the amount of foreign ownership of the uranium industry, transfer pricing is eliminated. The objective of maintaining adequate domestic supplies is pursued by estimating domestic requirements for the next 30 years and sharing responsibility for meeting these requirements among producers in proportion to reserves. Each producer's uncommitted uranium resources must be sufficient to meet its share of domestic requirements otherwise export contracts will not be

approved. A further restriction is that export contract approvals are limited to 15 years from date of signing. Since contracts are often entered into during the development state of a mine a contract may cover only 10 - 12 years of uranium supply which is not an overly long period in a market in which security of supply is the buyer's main concern. These provisions of the policy of maintaining adequate domestic supply are currently under review and are likely to be relaxed. Canada's uranium processing industry is still being developed and expanded. It will consist of a plant at Blind River, Ontario, which will have the capacity to convert U_3O_8 to UO_3 at a rate of 18,000 tonnes U. per year. The UO_3 will then be shipped to the processing plant at Port Hope which will be able to convert UO_3 to UF_6 for export at a rate of 9,000 tonnes U. per year and also to produce UO_2 for use by Candu reactors. Since the capacity of the domestic processing industry is likely to exceed domestic production for some considerable time to come the implication of federal policy is that all domestic production in the next ten years or so will be routed initially to Blind River. Canada's policy of attempting to restrict the use of its uranium to peaceful purposes has resulted in embargoes on exports to the EEC, Switzerland, Japan and Spain. Currently Switzerland and Spain are still not receiving Canadian uranium.

It is clear that federal policy tends to operate in the direction of reducing uranium exports. Higher prices and security of domestic supply can be achieved by restricting exports although in practice domestic reserves and production are so far in excess of domestic needs that the domestic supply constraint is not binding although it is possible that restrictions on sales contract terms make Canadian uranium less attractive to foreign buyers. To the extent that domestic processing costs are higher than those in the consuming countries the domestic processing policy tends to reduce the price received by producers for U_3O_8 and to lower output. The policy of attempting to restrict the use of Canadian uranium for peaceful purposes by means of embargoes tends to

increase the probability of an interruption in supply to the buyer and tends to make Canadian uranium less competitive in the world market. It should be stressed that while federal policy tends to reduce uranium exports the magnitude of the effect of each policy measure, with the exception of the policy of maintaining uranium prices, has probably been slight. It is difficult to guage the extent to which federal policy has reduced exports in an effort to maintain price because the restrictions tend to operate in informal as well as formal ways.

Since provincial tax receipts are extremely sensitive to uranium price the government of Saskatchewan shares the federal government's interest in restricting supply to maintain price. The provincial government has other policy concerns which are served by restricting the rate of development of the industry. The two most important of these are the desire to avoid environmental degradation and the desire to promote orderly social and economic development in the province, particularly in northern Saskatchewan.

The environmental and health problems associated with uranium mining have been the subject of a number of enquiries the most prominent of which in recent times have been the Ranger Uranium Environmental Inquiry in Australia and the Cluff Lake Board of Inquiry in Saskatchewan. Two principal recommendations of these exhaustive and comprehensive reviews of the uranium mining issue were the following: that the fragile environment in the locality of the mine be protected and that additional baseline data on the likely dispersion and effects of heavy metals and other pollutants on water and atmospheric systems be collected; and that full opportunity be given to local residents and in particular to aborigines or native indians to participate in the economic activity associated with the mine while at the same time extreme care be taken to ensure that local residents do not suffer social or economic deprivation. Both the Fox and Bayda commissions held

that these policy goals could be served by a policy of sequential development of uranium mines and mills in the region. This is a policy which has been termed one of attenuated mineral development.

The two principal advantages of the policy of attenuation are that the impact of the industry at any point in time on the local economy, environment, and social structure is lessened, and that an industry exploiting an exhaustible resource has a longer life. A smaller impact is of particular advantage when a policy goal is to involve local individuals and firms in supplying services to the mining firms. A large industry consisting of many mines would have to be supplied mainly from outside the region whereas an industry consisting of a few mines at any one time would provide a basis for continuing employment of a group of local individuals and firms. The longer life of the attenuated industry provides an opportunity for "learning-by-doing". As a result of the operations of the first few mines in the sequence a group of experienced workers and firms develops which can be drawn on by subsequent mines. While the first uranium mines and mills in the sequence of projects may be equipped with best practice techniques for environmental protection it is likely that pollution will occur because of unforeseen circumstances. The attenuated industry, however, is unlikely to inflict irreparable damage on the regional environment because of its reduced scale, and the experience of earlier mines can be incorporated in the design and operating procedures of subsequent ones. While an attenuated industry confers benefits on the local economy, society, and environment, the postponement of individual mining projects does have a cost and this aspect is discussed in the literature.

It is evident from the terms of the surface leases of the three new mines which have received approval to date that the government of Saskatchewan has placed considerable emphasis on local involvement in the uranium mining industry. For ex-

ample, among the terms of the Key Lake surface lease are that at least 50% of mine and mill staff should be northerners and that a fly-in programme be used to attract labour from existing northern communities. The Cluff Lake lease had a requirement that 50% of employees in the operating phase of the mine be native indians. The Key Lake lease also offers local business a 10% preference in bidding for contracts with the mining firms. This preferences will have its biggest impact during a mine's construction phase. For example, in the period August 1981 - December 1982 northern businesses obtained 20 contracts valued at $40.09 million or 49% of the value of contracts let for the construction of the Key Lake project. Because of its size and scope, however, the economy of northern Saskatchewan can support only a small number of mines without substantial recourse to outside labour and contractors. It follows that maximum involvement of northerners will be achieved by an attenuated industry and this is the course of development implied by the objectives of recent provincial policy.

The Cluff Lake and Key Lake Boards of Inquiry paid a considerable amount of attention to environmental problems associated with uranium mining. The terms of the Key Lake surface lease reflects this concern in that it imposes stringent conditions on the design and operations of the proposed mine and on the plans for reclaiming the site after extraction is completed. There is little evidence that the inquiries saw any notable advantage in terms of environmental protection to be gained from the reduced impact of an attenuated industry. On the other hand, it is likely that the increased opportunity for "learning-by-doing" afforded by sequential development did not escape the commissioners' attenuation. It is certainly the case that the time consuming process of gathering evidence on and deliberating over issues of environmental protection has effectively attenuated the earlier stage of the industry's development. As the learning process

continues the amount of time necessary for investigating proposals for new mines is likely to decrease. Nonetheless it is to be expected that a policy of gradual development will continue to be followed.

3 (iv) The Uranium Cartel

In 1972 a uranium marketing cartel called the Uranium Marketing Research Organization (UMRO) was formed to regulate the marketing of uranium in the non-communist world excluding the United States. The cartel members were the governments of Canada and Australia and the major uranium producing companies in these countries, Nufcor and Uranex, which are the corporations with government participation through which all sales of South African and French uranium are made, and Rio Tinto Zinc. The cartel agreed on quotas dividing the free world uranium market among its members, on uranium sales prices, and on a system of rigged bidding for supply contracts designed to ensure that members' quotas were filled at an even rate. The Canadian and Australian governments were to use the export licensing system to ensure that domestic companies observed the cartel rules, and the South African and French governments were to use their considerable influence on their country's marketing corporations.

In the period 1972-1974 in which the cartel is generally conceded to have operated the cartel floor price rose from \$5.50 to \$14.50 per lb U_3O_8 while the Nuexco US spot price rose from \$6 to \$14.50. Subsequently the spot price rose to a high of almost \$44 per lb in 1979. There have been a number of explanations besides the influence of the cartel for this dramatic price rise. The principal explanations appear to be a change in 1972 in the U.S. Atomic Energy Commission's enrichment policy in the direction of substituting U_3O_8 for energy in preparing enriched fuel, the 1975 default of Westinghouse, a principal dealer in the uranium market, on contracts to supply 49 reactors with fuel, and the 1979 rise in the price of OPEC oil. Westinghouse blamed its inability to meet its contracts on the activities of the cartel in raising uranium prices. While the cartel was not fully responsible for the large increase in price which occurred in the 1970's it is clear that a marketing organization which controlled over one third of low-cost

reasonably assured reserves could have considerable influence on price.

It is difficult to judge whether Canada is still colluding with the other large producers (apart from the U.S.) because restricting uranium output is consistent with other aims of government policy which were discussed above. Evidence that output will be restricted in order to maintain prices consists of the fact that this was federal government policy in the early 1970's and the federal government continues to maintain tight control of the terms of any new sales contract through its Uranium Export Review Panel. The government of Saskatchewan has attempted by various means to restrict the province's output of potash in order to maintain prices and there have been statements by government officials to the effect that development of uranium mines should not be allowed to proceed at a pace which would undermine the market. This philosophy has also been expressed by the Chairman of the Uranium Export Office in Australia and it seems likely that Canada and Australia will avoid price competition with one another.

If collusion does take place the price which operators of the new open-pit mines in Saskatchewan will receive for their uranium will be above the production cost of around $30/kg. U in 1979 dollars. The limiting price will probably be that at which U.S. requirements can be met by domestic sources. Industry analysts tend to agree that adequate supplies from the domestic industry should be forthcoming at least until 1990 without cost rising above $30/lb U_3O_8 (about $78/kg. U). This means that Saskatchewan's low-cost uranium can be sold at a price of $30/lb U_3O_8 at least until 1990 without suffering significant competition from the large U.S. uranium mining industry. The same conclusion has apparently been reached by the Australian government which has set a floor price of $30/lb U_3O_8 (1980 US dollars) below which it will not allow Australian uranium to be sold.

Any forecast of uranium prices beyond 1990 is obviously extremely speculative, but it can be noted that, provided those reserves in the category mineable at a uranium price up to $130/kg U. are increased by 35% over the period 1980-2020, the forecasted Canadian cumulative output of 825,000 tonnes U can be produced at a cost up to $130/kg U.

3 (v) The World Uranium Market and Canadian Production

In the four years 1979-1982 the price at which transactions in the uranium market were made fell from \$42.50/lb U_3O_8 to \$17.00/lb U_3O_8 according to NUEXCO estimates. Despite this extreme volatility medium-term projections of uranium supply and demand are relatively easy to make. Since both demanders and suppliers are commiting large amounts of capital well in advance (8-10 years) of deliveries there is a considerable amount of risk involved and an attempt is generally made to reduce this by means of long-term contracts (85-90% of the market) which assure buyers and sellers of being able to make transactions within some predetermined price range. This means that production over the next 8-10 years from existing and planned mines can be forecasted with a reasonable degree of certainty. The following Table reports estimates of Canadian uranium production by province:

Table 3.2: Estimated Canadian Uranium Production (tonnes U p.a.)

Year	Ontario	Saskatchewan	Total
1981	5,100	3,400	8,500
1982	5,100	3,400	8,500
1983	5,100	3,900	9,000
1984	5,800	7,000	12,800
1985	5,800	7,000	12,800
1986	5,700	7,000	12,700
1987	5,600	8,700	14,300
1988	5,500	8,700	14,200
1989	5,400	8,700	14,100
1990	5,100	8,700	13,800

(Source: O.J.C. Runnalls Ontario's Uranium Mining Industry - Past, Present and Future)

In order to predict uranium production over the longer term it is necessary to forecast domestic and world demand and supply. It is forecasted that Ontario Hydro will account for almost all the domestic demand for uranium until 1995. Thereafter demand for uranium by Quebec Hydro and the New Bunswick Electric Power Commission may constitute a more significant portion of domestic demand depending on the availability of alternative sources of energy. Other provinces may also decide to establish nuclear power plants. Since Ontario producers have extensive commitments to supply Ontario Hydro until 2011 (Dennison) and 2020 (Rio Algom) a reasonable assumption for forecasting purposes might be that domestic demand can and will be met out of Ontario's uranium production and that sales of Saskatchewan uranium will depend on export demand.

The estimation of world uranium demand beyond the period during which currently commissioned reactors will become operational is fraught with three principal uncertainties; first, it is difficult, especially in the light of recent experience, to predict the growth of electricity demand; secondly, in view of the problems experienced by operating nuclear plants and the delays associated with licensing and constructing new plants it is difficult to forecast the proportion of electricity demand which will be generated by nuclear power; and, thirdly, uncertainty about the type of nuclear fuel cycle to be used in the future can lead to wide variations in predictions of uranium demand. The following list of uranium demand estimates illustrates the effect of these uncertainties. Each forecast consists of a range of estimates, of which only the lowest and highest are reported here, contingent on the assumptions made in the three areas mentioned above. The wide range of estimates in each forecast and the considerable disparity among forecasts suggests that little confidence can

Alternative Forecasts of World*

Uranium Demand, 1995-2020

Forecast			Years			
			1995	2000	2010	2020
			(thousands of tonnes U)			
WEC[1]	(1978)	low	-	190	-	350
		high	-	220	-	600
OECD[2]	(1977)	low	104	125	-	-
		high	234	338	-	-
OECD[3]	(1982)	low	64	81	54	55
		high	93	129	178	317
Uranium[4] Institute	(1981)	low	65	-	-	-
		high	108	-	-	-

(Sources: 1. Canada, Energy Mines and Resources (1978)
2,3 OECD (1977, 1982)
4 Uranium Institute (1981)

*World excluding the USSR, Eastern Europe, and China

be placed in any particular set of estimates. Nevertheless, for the purposes of this study it is necessary to have a forecast of uranium demand and the one selected is the World Energy Conference's (WEC) low estimate of 190,000 tonnes in 2000 and 350,000 tonnes in 2020. While this is at the low end of the range of WEC estimates it is at the high end of the range of forecasts cited. Since almost all the impact estimates which are reported in this study are linearly related to uranium demand it is an easy matter for the reader to calculate the impact of the industry under alternative assumptions about demand and production.

Based on estimates of uranium resources prepared by WEC, OECD, and Energy, Mines and Resources, Canada, Canada's share of the world's reasonably assured uranium resources recoverable at costs up to $130/kg U is around 10%. The 10% share in the world uranium market assigned to Canada in the forecast of production to 2020 is substantially less than Canada's 20% share in world production in 1978. By 1990 Canada's share is predicted to fall to 13% and to decline even further in the 1990's. There are two main reasons for predicting a decline. First, the United States which ranks first in the world in terms of what are called low-cost (up to $130/kg. U) reasonably assured uranium resources has indicated its readiness to protect its uranium producing industry against foreign competition if necessary. This means that Canadian producers may have a declining share of the expanding U.S. market. Secondly, since South Africa and Australia have become the first and second ranked countries after the United States in terms of low-cost reasonably assured resources they can be expected to increase their share of the world market. This is especially true in the case of Australia which has recently seen substantial increases in its reserves to about 14% of low-cost reasonably assured resources but which currently has only about 6% of world uranium production. Evidence of Australia's ability to expand its share of the market is that since 1980 it has secured a larger tonnage of export contracts than Canada.

If Canada were to fill 10% of world demand as estimated by the WEC it would require to produce 19,000 tonnes U p.a. by 2000 and 35,000 tonnes U p.a. by 2020. Given current estimates of reserves it is likely that Saskatchewan will have a substantial share of the Canadian industry by 2000. A reasonable assumption might be that Ontario's production will be maintained at the forecasted

level for 1990 and that Saskatchewan will account for the rest of Canada's production. This means that Saskatchewan would produce 14,000 tonnes U in the year 2000, about 75% of the country's total output. By the year 2000 exploration in other parts of Canada, in the Northwest Territories for example, will probably have located additional low-cost uranium reserves. The development of these reserves will result in a decline in Saskatchewan's share of Canadian production and for the purposes of the present study it will be assumed that this share stands at 50% in the year 2020.

To review the implications of these forecasts, Saskatchewan's production is forecasted to rise to 8,700 tonnes U p.a. in 1990, as indicated by the Table of estimates and then to rise linearly to 14,000 tonnes U. p.a. in the year 2000. After 2000, Canada's output is forecasted to rise linearly to 35,000 tonnes p.a. in 2020, with Saskatchewan's share falling linearly from 75% in 2000 to 50% in 2020. The following Table reports the forecasts of Canadian and Saskatchewan output.

Table 3.3: Forecast of Annual Uranium Output of Saskatchewan and Canada, 1981-2020

Year	Output		Year	Output	
	Saskatchewan tonnes U. pa	Canada tonnes U.pa		Saskatchewan tonnes U. pa	Canada tonnes U. pa
1981	3,400	8,500	2001	14,226	19,800
1982	3,400	8,500	2002	14,564	20,600
1983	3,900	9,000	2003	14,969	21,400
1984	7,000	12,800	2004	15,185	22,200
1985	7,000	12,800	2005	15,468	23,000
1986	7,000	12,700	2006	15,732	23,800
1987	8,700	14,300	2007	15,978	24,600
1988	8,700	14,200	2008	16,205	25,400
1989	8,700	14,100	2009	16,414	26,200
1990	8,700	13,800	2010	16,605	27,000
1991	9,220	14,320	2011	16,777	27,800
1992	9,740	14,840	2012	16,931	28,600
1993	10,260	15,360	2013	17,067	29,400
1994	10,780	15,880	2014	17,184	30,200
1995	11,300	16,400	2015	17,283	31,000
1996	11,820	16,920	2016	17,363	31,800
1997	12,340	17,440	2017	17,425	32,600
1998	12,860	17,960	2018	17,468	33,400
1999	13,380	18,480	2019	17,493	34,200
2000	13,900	19,000	2020	17,500	35,000
Cumulative	182,100	287,300		327,837	548,000

These estimates of uranium output involve cumulative Canadian production of 287,300 tonnes U by 2000 and 835,300 tonnes U by 2020. These cumulative production figures can be compared with 1979 estimates of Canadian reserves in the measured, indicated, inferred and prognosticated categories mineable at uranium prices up to $130/kg. U of 611,000 tonnes, and additional reserves mineable at prices up to $200/kg. U of 348,000 tonnes U. Since exploration will probably result in an increase in reserves mineable at prices up to $130/kg. U it is probably safe to assume that production costs in Canada in the year 2020 will be less than $130/kg. U(1979 dollars)in real terms. The bulk of current Canadian uranium exploration is taking place in Saskatchewan and a significant increase in that province's reserves can be anticipated. Saskatchewan's current reserves are estimated to be about one third of Canadian reserves which would constitute about 204,000 tonnes mineable at prices up to $130/kg. U and 116,000 tonnes mineable at prices up to $200/kg. U. In terms of the forecast of Saskatchewan production all the forecasted output to the year 2000 can be met out of existing reserves in the low-cost category. Thereafter discoveries corresponding to 160% of existing low-cost reserves will be necessary to maintain production at a cost below $130/kg. U (1979 dollars) in real terms.

In the absence of a formal model it is difficult to estimate the amount of exploration which will be required to produce the additions to provincial reserves described above. The standard model of reserves production from a new exploration territory such as the Athabasca basin would predict that for a constant level of exploratory effort annual additions to reserves would increase at first, reflecting the contribution of additional knowledge about the geology of the region, and then decrease once the larger and more easily-located deposits had been located. Since this pattern of discovery would not be inconsistent with

the production estimates and current reserve information reported above it will be assumed that uranium exploration expenditures in Saskatchewan remain at $50 million (1980 dollars) per annum in real terms throughout the forecast period. This is slightly above the average level of expenditures during the period 1977-82 which saw annual expenditures rise from $40 million in 1977 to $77 million in 1980 and then fall to $45 million in 1982.

The forecasts of world uranium demand which have been discussed here are made with no reference to uranium price. Since the demand for uranium is derived from the demand for electric power and since uranium fuel costs are a very small proportion of the cost of generating electricity by nuclear means the long-run demand curve for uranium is likely to be fairly inelastic. This means that quantity demanded will not vary much with price and this justifies to some extent forecasts of demand which take no account of price. On the other hand, the price of uranium will be sensitive to the quantity supplied and this raises the possibility that concerted action to reduce supply could result in significant resource rents accruing to suppliers. In the case of Saskatchewan uranium a large proportion of resource rents accrues to the provincial government through its uranium royalties scheme. Since these rents may be used to finance economic development in the province it is important in the present study to come to view about future uranium prices as well as production.

It was argued earlier that a price of around $78/kg. U (30/lb U_3O_8) represent a price at which U.S. and high-cost Canadian producers can easily cover costs. The aim of the low-cost Canadian and Australian producers will be to maintain price at close to this level thereby collecting substantial rents. For the purposes of the present study it will be assumed that the price of uranium is $70/kg. U (1980 dollars) in real terms until the year 2000. This

represents a price of around \$27/lb U_3O_8 which is slightly higher than the current price. As production continues beyond the year 2000 real price of uranium will rise reflecting cost increases among the high cost producers. It will be assumed that the price is \$100/kg. U (1980 dollars) in real terms from 2000-2020. The price of \$70/kg. U yields a rent of \$40/kg. U to the Key Lake operation while the price of \$100/kg. U is roughly double the current cost of production in Ontario.

3 (vi) The Impact of Uranium Production on the Economy of Saskatchewan

The Saskatchewan uranium industry will have direct and indirect effects on the provincial economy. The direct effects consist of the employment and income impacts generated within the industry itself while the indirect effects consist of employment and income generated in other industries as a result of the linkages between the uranium industry and the rest of the economy. There are three kinds of linkages which are normally considered in an estimation of the indirect impact of an industry: the effects on industries which supply inputs to the industry in question are termed backward linkages; the effects on industries which demand the output of the industry in question are termed forward linkages; and the effects of complementary developments such as mining towns are termed sideways linkages. In the present study backwards linkages alone are considered. The forward linkages will be felt mainly in Ontario where the uranium processing industry is located and the sideways linkages are likely to be small because of the provincial government's "fly-in" policy under which employees will be flown into the mine sites from established communities.

The three kinds of expenditures undertaken by the uranium mining industry which will have backward linkages with the provincial economy are exploration expenditures, expenditures associated with mine and mill development, and expenditures associated with mine and mill operation. In section 3(v) a figure of $50 million (1980 dollars) was adopted as the estimate of annual exploration expenditures. Table 3.3 reported estimates of the annual outputs of uranium resulting from mine and mill operation over the period 1981-2020. Mine and mill development expenditures sufficient to sustain those levels of uranium output over that period will have to be incurred. New mine/mill complexes will be required to provide increments to industry capacity and to replace mines

which become exhausted. Since uranium mines have an average life of around 12 years some 40,000 tonnes of uranium producing capacity will have to be installed in the years 1981-2020 to meet the estimate of cumulative production reported in Table 3.3. It was suggested in section 3(iii) that an objective of provincial policy was to maintain a stable construction industry based on mine and mill development. This would imply that approximately 1,000 tonnes of uranium producing capacity would be constructed in each year from 1981 to 2020 and this is the assumption which will be adopted in the estimates of backward linkages.

The magnitude of backward linkages on the provincial economy is measured using multipliers derived from the inter-provincial input-output table. There are two kinds of multipliers in general use: multiplier type A can be defined as the ratio of change in provincial income to change in the value of industry output; type B can be defined as the ratio of change in provincial income to change in industry value added. Since the change in industry output is almost always larger than the change in value added, type B multipliers are larger than type A but the forecasts of industry impact should be the same. In the present study type B multipliers will be used. This means that estimates of the cost-breakdowns for the various industry expenditures are required to provide the base for the multiplier calculation. Measures of backward linkages derived from multipliers are virtually certain to represent upper-bound estimates of the direct and indirect effects of the industry on extensive growth. They also offer no insights regarding the contribution of backward linkages to intensive growth in Saskatchewan. The reason is that the use of multipliers assumes that supplies of labour, capital and intermediate inputs are available at constant factor prices and are not currently employed in the Saskatchewan economy. To the extent, for example, that the backward linkages of the uranium industry lead to an internal reallocation of factors within the provincial economy there is no

extensive growth in the province. Or if the backward linkages are satisfied by attracting labour from elsewhere in Canada the extensive growth of Saskatchewan corresponds to a contraction elsewhere in Canada. In either of these two cases, mobile factors are merely being reallocated at constant factor prices so that there is no net impact on income per capita. Only if the factors use unemployed and in Saskatchewan would intensive growth increase in the province as a result of the backward linkages.

Table 3.4: Income and Employment Impact of Uranium Exploration in Saskatchewan

Income Impact (millions of 1980 dollars)			Employment Impact (jobs)		
Annual Expenditure	=	50			
Provincial Value Added	=	34.5	Direct	=	1144
Multiplier	=	1.34	Multiplier	=	1.39
Total Annual Impact	=	46.23	Total	=	1590

(Source: derived from Marvin Shaffer and Associates Ltd (1982), pp. 54 - 55)

It is estimated that the capital cost of a typical open-pit uranium mine and mill is around $110 million per thousand tonnes of metal output capacity. Of this sum, construction labour accounts for around 22% and equipment, materials and services the remaining 78%. The construction labour input is estimated to be around 600 man-years per thousand tonnes of capacity. Using these figures the following estimates of the impact on the provincial economy of the construction of one thousand tonnes of uranium producing capacity can be obtained.

Table 3.5: Income and Employment Impact of Investment in Uranium Production Capacity in Saskatchewan

	Income Impact ($ millions)		Employment Impact (jobs)	
Annual Capacity Constructed	= 1000 tonnes			
Provincial Value Added	= 24.2	Direct	=	600
Multiplier	= 2.5	Multiplier	=	3
Total Annual Impact	= 60.5	Total	=	1800

(Source: Marvin Shaffer and Associates Ltd (1980))

The provincial value-added component of a dollar's worth of uranium metal is highly sensitive to the price of uranium. Two price levels are considered in the present study. Until 2000 the price is assumed to be $70/kg. U (1980 dollars), and from 2000-2020 to be $100/kg. U (1980 dollars). The following Table reports estimates of the operating cost structure of an open-pit uranium mine and mill in Saskatchewan under each of these price assumptions:

Table 3.6: Operating Costs per Kilogram of Uranium Output for an open-pit mine in Saskatchewan

Input Cost	1980 $	
	Price = $70	Price = $100
Material and Service Costs	5.81	6.10
Gross (pre-tax) Labour Cost	4.13	5.50
Government Revenue		
- federal corporate income tax	12.32	15.30
- provincial corporate income tax	4.48	5.20
- provincial royalty	16.10	29.80
Gross Operator Margin	27.16	38.10
Total Unit Value (f.o.b. Mill)	70.00	100.00

(Source: Marvin Shaffer and Associates Ltd (1980), Table 3.1 and 3.2)

It can be seen from Table 3.6 that provincial value added, which is the sum of all input costs except material and service costs is highly sensitive to uranium price. Since provincial value added plays a critical role in determining the overall economic impact it is clear that the uranium price assumption is a critical one in the impact estimates. For the present the impact calculations will be carried out on the assumption that provincial government receipts, which are the largest component of value added (see Table 3.10), are disposed of in a way which involves no impact on the provincial economy. This assumption will be relaxed later.

The annual economic impact of operating a facility producing 1,000 tonnes U per annum for the two prices under consideration is reported in the following Table:

Table 3.7: Annual Economic Impact of Operating 1,000 tonnes U p.a. Capacity

(millions of 1980 $)

Price = $70/kg. U		Price = $100/kg. U	
Provincial Value Added	= 64.2	Provincial Value Added	= 93.9
Multiplier	= 1.04	Multiplier	= 1.04
Total Annual Impact	= 66.6	Total Annual Impact	= 97.4

(Source: derived from Marvin Shaffer and Associates Ltd. (1980) Chapters 3 and 4)

The annual employment impact of operating a 1,000 tonnes U per annum plant is given by the following Table:

Table 3.8: Employment Created by Operating 1,000 tonnes U p.a. Capacity

		(jobs)
Direct impact	=	225
Multiplier	=	1.49
Total	=	335

(Source: Marvin Shaffer and Associates Ltd (1980, Table 4.3)

The annual impacts of the exploration, development and production activities associated with the uranium mining industry are summarized in Table 3.9. The contributions to gross domestic provincial product are calculated from the impacts reported in Tables 3.4, 3.5 and 3.7 together with the annual uranium production estimates reported in Table 3.3. The employment impacts are estimated from Tables 3.4, 3.5 and 3.8 together with the production figures of Table 3.3. To place the impact estimates in perspective it is helpful to compare them with current levels of production and employment in the province. The following Table shows the uranium industry's forecasted contributions to gross domestic provincial product and employment for selected years as percentages of 1980 provincial product and employment levels. This procedure adopted for Table 3.10 (and 3.18 to follow) assumes no growth in the Saskatchewan and national economies other than from the province's uranium industry.

Table 3.10: Impacts of Saskatchewan's Uranium Industry Expressed as Percentages of 1980 Product and Employment Levels

Year	Contribution to GDPP	Employment	Employment
	1980 GDPP	Total Mining Employment	Total Non-Agricultural Employment
	%	%	%
1981	2.54	52	1.7
1990	5.24	72	2.3
2000	7.90	92	2.9
2001	11.41	93	3.0
2010	13.20	103	3.3
2020	13.87	106	3.4

(Sources: Statistics Canada 13-213 and 72-008, and Table 3.9)

Table 3.9: Estimated Annual Impact of Saskatchewan's Uranium Industry on the Provincial Economy

	Contribution to GDPP (millions 1980$)				Contribution to Provincial Employment (Jobs)			
Year	Explor'n	Develop't	Prod'n	Total	Explor'n	Develop't	Prod'n	Total
1981	46	61	226	333	1590	1,800	1,139	4529
1982	46	61	226	333	1590	1,800	1,139	4529
1983	46	61	260	367	1590	1,800	1,307	4697
1984	46	61	466	573	1590	1,800	2,345	5735
1985	46	61	466	573	1590	1,800	2,345	5735
1986	46	61	466	573	1590	1,800	2,345	5735
1987	46	61	579	686	1590	1,800	2,915	6305
1988	46	61	579	686	1590	1,800	2,915	6305
1989	46	61	579	686	1590	1,800	2,915	6305
1990	46	61	579	686	1590	1,800	2,915	6305
1991	46	61	614	721	1590	1,800	3,089	6480
1992	46	61	649	756	1590	1,800	3,263	6653
1993	46	61	683	790	1590	1,800	3,437	6827
1994	46	61	718	825	1590	1,800	3,611	7001
1995	46	61	753	860	1590	1,800	3,786	7176
1996	46	61	787	894	1590	1,800	3,960	7350
1997	46	61	822	929	1590	1,800	4,134	7524
1998	46	61	856	963	1590	1,800	4,308	7698
1999	46	61	891	998	1590	1,800	4,482	7872
2000	46	61	926	1,033	1590	1,800	4,657	8047
2001	46	61	1,386	1,493	1590	1,800	4,766	8156
2002	46	61	1,419	1,526	1590	1,800	4,879	8269
2003	46	61	1,458	1,565	1590	1,800	5,015	8405
2004	46	61	1,479	1,586	1590	1,800	5,087	8477
2005	46	61	1,507	1,614	1590	1,800	5,182	8572
2006	46	61	1,532	1,639	1590	1,800	5,260	8660
2007	46	61	1,556	1,663	1590	1,800	5,353	8743
2008	46	61	1,578	1,685	1590	1,800	5,429	8819
2009	46	61	1,599	1,706	1590	1,800	5,499	8889
2010	46	61	1,617	1,724	1590	1,800	5,563	8953
2011	46	61	1,634	1,741	1590	1,800	5,620	9010
2012	46	61	1,649	1,756	1590	1,800	5,670	9062
2013	46	61	1,662	1,769	1590	1,800	5,717	9107
2014	46	61	1,674	1,781	1590	1,800	5,757	9147
2015	46	61	1,683	1,790	1590	1,800	5,790	9180
2016	46	61	1,691	1,798	1590	1,800	5,817	9207
2017	46	61	1,697	1,804	1590	1,800	5,837	9227
2018	46	61	1,701	1,808	1590	1,800	5,852	9242
2019	46	61	1,704	1,811	1590	1,800	5,860	9250
2020	46	61	1,705	1,812	1590	1,800	5,863	9253

It can be seen from Table 3.10 that the uranium industry's current contribution to gross domestic provincial product is estimated to be a relatively modest 2.54%. While the absolute contribution of the industry to GDPP increases almost sixfold over the period 1981-2020 a continuous growth rate of around 4.3% in GDPP would be enough to keep the industry's relative contribution to its current level. It can be seen that the percentage contribution increases considerably between 2000 and 2001 because this is the point at which the uranium price is assumed to increase from $70/kg. U to $100/kg U. In practice, of course, the price increase is likely to be a gradual one. As far as employment is concerned, the uranium industry is a significant part of the mining industry. Nonetheless direct and indirect employment generated by the uranium industry is forecasted to reach by 2020 a level of only 3.7% of non-agricultural employment in 1980.

Of course the accuracy of the estimates of economic impact presented above depends heavily upon the accuracy of the uranium output and price forecasts on which they are based. It should be emphasized once again that these forecasts are highly speculative and that the reader can readily adjust the impact estimates to accommodate alternative demand forecasts. Besides the questionable accuracy of the output and price forecasts there are some additional factors which may lead to error in the impact forecasts. First, it will be recalled that no attempt was made to account for complementary linkages such as the impact of producing additional transport,municipal and housing services in the north. Secondly, in view of the provincial government's emphasis on the participation of local businesses in the uranium industry it is possible that the direct impacts of the exploration, development, and production activities have been underestimated. This is particularly likely to be true in the case of mine and mill development. Thirdly, since a high proportion of the direct impact of the operating phase of a uranium mine/mill complex consists of tax revenue it is clear that the economic impact of uranium mining will be influenced considerably by the use to which these revenues are put.

The cost breakdowns reported in Table 3.6 were based on the Cluff Lake mine, in which the Saskatchewan Mining and Development Corporation (SMDC) has a 20% interest, and the Key Lake mine in which SMDC has a 50% interest. If it is assumed that the average SMDC interest is 35% then the proportion of the total value f.o.b. the mill of a kilogram of uranium which accrues to the provincial government can be calculated as follows:

Table 3.10: Provincial Government Receipts per Kilogram of Uranium Produced

	Price/kg. U (1980 $)	
	$70	$100
Provincial Corporate Income Tax	4.48	5.20
Provincial Royalty	16.10	29.80
SMDC Share of Gross Operator Margin	9.51	13.34
Total Provincial Receipts	30.08	48.34

These estimates of total provincial receipts per kilogram of uranium will understate future receipts if SMDC elects to acquire 50% of the equity in future developments as it was entitled to do under provincial legislation until recently when the requirement that a mining company had to allow SMDC to acquire up to 50% of its equity was abandoned. From Tables 3.3 and 3.10 the following estimates of provincial receipts for selected years can be obtained.

Table 3.11: Provincial Government Receipts from the Uranium Industry for Selected Years

Receipts (millions 1980 $)

Years	Income Tax	Royalty	SMDC	Total
1981	15	55	32	102
1990	39	140	83	262
2000	62	224	132	418
2001	74	424	190	688
2010	86	495	222	803
2020	91	522	233	846

The considerable jump in receipts between 2000 and 2001 is caused by the assumption that the higher price of uranium comes into effect in the latter year. Provincial royalty receipts are particularly sensitive to changes in uranium price.

Of the three categories of provincial receipts only the provincial royalties are classified as non-renewable resource revenues. The provincial share of corporate income tax is a tax on the earnings of physical capital the proceeds from which are allocated to general revenue. The revenues which accrue to SMDC are a return to investment in the uranium industry: SMDC purchases equity in discoveries by private companies and it conducts about half of the exploration for uranium in the province. The provincial royalty receipts are paid into the Saskatchewan Heritage Fund which also receives other non-renewable resource revenues. In the 1981-82 financial year uranium royalties totalling $30 million were paid into the fund. This is considerably less than the forecast figure of around $55 million because of the slump in the price of uranium in those years. The major contributor to the Heritage Fund at present

is the oil industry which contributed 64% of 1981-82 revenues. The potash industry contributed 22% while the uranium industry's contribution was 3.6% of Fund revenues. The estimates in Table 3.11 indicate that by the year 2020 the uranium industry will be contributing $522 million (1980 dollars) per annum to the Heritage Fund. This is roughly equal to the 1981-82 contribution of the oil industry, and so, in a sense, the uranium industry will replace the declining oil industry.

Of the Heritage Fund revenues any proportion can be transferred as a dividend to the Consolidated Fund to help finance current government revenues. In 1981-82 a dividend of 70% of Fund revenues was paid. The remaining portion of revenue was used for provincial development expenditures (6 1/2%) incentive grants for the petroleum and natural gas industry (7%), and investment in various crown corporations including SMDC which is engaged in a programme of mineral exploration and mine development.

To this point in the study no attempt has been made to estimate the indirect effects of spending out of government revenue and operator margin. The implicit assumption made is that the appropriate multiplier for calculating the total effects of spending out of these receipts is unity. In fact this may not be a very inaccurate assumption as far as private profit margins and federal taxes are concerned since first round spending in Saskatchewan from these sources will be low. Where this assumption is likely to be particularly inaccurate is in the case of provincial receipts.

As indicated in Table 3.11 provincial government receipts from the uranium industry take three principal forms: the provincial corporate income taxes which accrue to the Consolidated Fund; the uranium royalties which accrue

initially to the Heritage Fund but a portion of which is transferred in the form of a dividend to the Consolidated Fund; and SMDC's share of the private profit margin some of which is reinvested in the industry and some paid as a dividend to the Heritage Fund. Additions to the Consolidated Fund will be used to finance some combination of reducing taxes paid by Saskatchewan residents and increasing provincial government expenditures. The Heritage Fund revenues, net of those transferred to the Consolidated Fund, will be used to foster provincial economic development. The revenues accruing to SMDC, net of those transferred to the Heritage Fund, will be used further to develop the provincial mining industry: some of the expenditures which will be undertaken in this regard are included in the estimates of uranium exploration and development expense reported in Table 3.9; others will be of a more general nature. To the extent that SMDC finances exploration and development which would have been undertaken by the private sector it is simply transferring ownership of assets from the private to the public sector and this will involve no indirect economic impact. In summary, the indirect economic impacts which remain to be estimated are those associated with SMDC investment expenditures not already accounted for, expenditures out of the Heritage Fund, and the disposition of additions to the Consolidated Fund.

In order to generate some estimates of the magnitude of these additional indirect impacts the following assumptions will be adopted: first, that SMDC revenues will be divided equally among the Heritage Fund, expenditures already accounted for in Table 3.9, and further investment expenditures in the mineral industry; secondly, that 70% of Heritage Fund revenues will be transferred to the Consolidated Fund; and, thirdly, that of additions to the Consolidated Fund half will be used to finance tax cuts and half to finance increased levels of

government expenditure. On the basis of these assumptions and using the estimates of receipts reported in Table 3.11, the following set of estimates of expenditures with indirect impacts which are not incorporated in Table 3.9 is obtained:

Table 3.12: Categories of Additional Government Expenditure Resulting from Uranium Receipts, Selected Years

	Uses of Funds (millions 1980$)		
	(1)	(2)	(3)
Year	Tax Reduction	Increase in General Gov't Expenditure	Gov't Development Expenditures
1981	30.5	30.5	31
1990	78.5	78.5	78
2000	125.0	125.0	124
2001	207.5	207.5	209
2010	242.0	242.0	245
2020	255.5	255.5	258

Each of these uses of funds will have an impact on the provincial economy not already accounted for in Table 3.9. Excluding the direct impact of these funds which is already accounted for the indirect impacts per $1,000 of expenditure can be estimated from the Interprovincial Input-Output model. The estimates reported in Table 3.13 are obtained from the inverse of the closed version of the provincial input-output model. They are likely to exaggerate the indirect impact of government spending on real GDPP for two reasons: first, the closed version of the input-output model makes no allowance for import leakages; and, second, the model assumes perfectly elastic factor supplies.

Table 3.13: Indirect Impacts of $1,000 Expenditure on Three Categories

Category	Indirect Impact ($)
Tax Reduction	283
Gov't Development Expenditure	685
General Gov't Expenditure	1,030

(Source: Gaston and Bédard (1980), Table III A8, Gross Domestic Product, Final Demand Categories - Transfers to Persons, Construction, and Government)

From Tables 3.12 and 3.13 the indirect impacts arising out of the allocation of provincial receipts can be estimated. These are reported in Table 3.14.

Table 3.14: Indirect Impacts of Government Expenditures, Selected Years

	Impacts (millions 1980$)			
Year	(1) Impact of Tax Reduction	(2) Impact of General Gov't Expenditure	(3) Impact of Gov't Development Expenditure	Total Impact
1981	9	31	21	61
1990	22	81	53	156
2000	35	129	85	249
2001	59	214	143	416
2010	68	249	168	485
2020	72	263	177	512

The Interprovincial Input-Output Model also allows the employment effects of increases in various categories of final demand to be estimated and these are reported in Table 3.15:

Table 3.15: Employment Effects of $10 million Expenditure on Three Categories

Category	Indirect Impact (person years)
Tax Reduction	175
Gov't Development Expenditure	291
General Gov't Expenditure	873

(Source: Gaston and Bédard (1980), Table III A8, Employment, Final Demand Categories - Transfers to Persons, Construction, and Government)

From Tables 3.12 and 3.15 the following estimates of the employment effects of government expenditure out of receipts from the urnaium mining industry can be calculated:

Table 3.16: Employment Effects of Government Expenditures, Selected Years

Impact (jobs)

Year	Impact of Tax Reduction	Impact of General Gov't Expenditure	Impact of Gov't Development Expenditure	Total Impact
1981	534	2,663	902	4,099
1990	1,374	6,853	2,270	10,497
2000	2,188	10,913	3,608	16,709
2001	3,631	18,115	6,082	27,828
2010	4,235	21,127	7,130	32,492
2020	4,471	22,305	7,508	34,284

In Table 3.17 the impacts of the industry's activity together with those of additional government expenditure are summarized for purposes of comparison. It can be seen that the indirect impacts of government spending out of receipts

from the industry as a percentage of total impact rises from 15% in 1981 to 22% in 2020. The reason for this is that provincial government receipts and hence expenditures are a high and, over time, rising

Table 3.17: Summary of the Uranium Industry's Impact, Selected Years

Year	(1) Direct and Indirect Industry Impact		(2) Indirect Impact of Additional Government Spending		(3) Total Impact	
	Contribution to GDPP (millions 1980$)	Contribution to Employment (jobs)	Contribution to GDPP (millions 1980$)	Contribution to Employment (jobs)	Contribution to GDPP (millions 1980$)	Contribution to Employmen (jobs)
1981	333	4,529	61	4,099	394	8,628
1990	686	6,305	156	10,497	842	16,802
2000	1,033	8,047	249	16,709	1,282	24,756
2001	1,493	8,156	416	27,828	1,909	35,984
2010	1,724	8,953	485	32,492	2,209	41,445
2020	1,812	9,253	512	34,284	2,324	43,537

(Source: Tables 3.9, 3.14, and 3.16)

proportion of industry value added. Table 3.18 reports the figures entered in Table 3.17 as percentages of current provicial values for comparison purposes:

Table 3.18: Industry and Government Expenditure Impacts Expressed as Percentages of 1980 Product and Employment Levels

Year	Contribution to GDPP as % of 1980 GDPP			Contribution to Employment as % of Total Non-Agricultural Employment 1980		
	Industry	Gov't	Total	Industry	Gov't	Total
1981	2.54	.46	3.00	1.7	1.54	3.24
1990	5.24	1.19	6.43	2.3	3.83	6.83
2000	7.90	1.90	9.80	2.9	6.02	8.92
2001	11.41	3.18	14.59	3.0	10.24	13.24
2010	13.20	3.71	16.91	3.3	11.98	15.28
2020	13.87	3.92	17.79	3.4	12.60	16.00

(Sources: Tables 3.10 and 3.17)

It will be evident that provincial government policy plays an important part in determining the overall impact of the industry on GDPP. The extent of this impact can be seen from Table 3.19: column (1) reports the direct government spending out of tax revenues from the industry; column (2) reports the indirect impact of government spending; and column (3) reports the sum of the direct and indirect impacts. It can be seen from column (3) that between 29% and 41% of total industry impact on GDPP results from government tax and expenditure policies. In other words, as compared with a situation in which provincial taxation was limited to collecting taxes and passing them on in the form and amounts of the tax reductions reported in column (1) of Table 3.12, and assuming that the federal taxes and the operator margins implied by this policy contributed to no spending within the province, the industry impact on GDPP is up to 41% higher as a result of provincial government policy. Assuming that the present tax

Table 3.19 The Direct and Indirect Impacts of Government Expenditures on GDPP

Year	(1) Direct Impact		(2) Indirect Impact		(3) Total Gov't Impact	
	Millions 1980 $	% of Total Impact	Millions 1980 $	% of Total Impact	Millions 1980 $	% of Total Impact
1981	61.5	16	52	13	113.5	29
1990	156.5	19	134	16	290.5	35
2000	249.0	19	214	17	463.0	36
2001	416.5	22	357	19	773.5	41
2010	487.0	22	417	19	904.0	41
2020	513.5	22	440	19	953.5	41

(Sources: Table 3.12 columns 2 and 3; Table 3.14 columns 2 and 3; Table 3.17 column 3.)

structure is maintained the provincial government still has considerable latitude in determining how large should be the uranium industry's impact on GDPP. At one extreme it would be technically possible to sterlize provincial tax receipts by investing them, and the interest earned on them, abroad. The impact of the industry over the forecast period would then be limited to the estimates reported in column (1) of Table 3.17. The impacts reported in column (2) of the Table 3.17 would occur at some future time at which the capital and interest invested abroad were repatriated and spent in roughly the manner described in the paper. At the other extreme it would be possible to achieve indirect impacts of government expenditure in excess of those reported in columns (2) of Table 3.17 by increasing the proportion of provincial receipts used to finance increases in government expenditure. This is the use of funds which has the highest multiplier effect on the provincial economy.

Finally, this section on the impact of the uranium industry on the economy of Saskatchewan can be concluded by a review of the assumptions underlying the estimates summarized in Table 3.17. There are four critical sets of assumptions, three of which almost certainly impart an upward bias to the impact estimates. These sets of assumptions are those about quantities of uranium produced; those about uranium prices; those about the disposition of government revenues; and those underlying the multiplier estimates used to calculate the indirect effects of government expenditure.

The quantity and price assumptions are possibly optimistic. From the world uranium demand forecasts reported on page 3.16 it can be seen that world demand, and hence, by assumption, Saskatchewan's production, may on the basis of the low OECD estimates, be 43% and 16% respectively of the estimates used in this study for the years 2000 and 2020. This would mean, for example, that, other things remaining equal, the actual impact in the year 2000 would be slightly less than the one reported for 1990. The $70 per kg. U price is probably a reasonable estimate but the forecasted jump from $70 to $100 per kg U in real 1980 dollars around 2001 is highly speculative. As was noted earlier provincial government receipts and expenditures are sensitive to uranium price and it is possible that the additional impacts on GDPP, consequent upon this increase in price, which were reported for the years 2001-2020 may not take place.

The estimates of the disposition of government revenues from the uranium industry were not intended as a forecast of provincial policy. They are based partly on recent policy towards nonrenewable resource revenues in Saskatchewan and Alberta and partly on arbitrary assumptions. It was noted that the impact multipliers for computing the indirect effects on GDPP of the disposition of

government revenues range from unity in the sterlization case to 2.03 in the case of general government expenditure. Given this range of multipliers it is obvious that the estimate of the indirect impact resulting from the use of provincial revenues is sensitive to the assumptions made about the disposition of those revenues.

The multipliers used to estimate the indirect impact of government expenditures and tax reductions are based on a model of the provincial economy which makes no allowance for imports. The import leakages from the provincial income flow are likely to be significant and their inclusion in the model of the provincial economy could have a substantial effect on the values of the various multipliers. A simple example will illustrate this point: if an import leakage of 20% is added to a standard Keynsian closed model with a multiplier of 2.03, as was used for general provincial government expenditures, the value of the multiplier falls to 1.44. Changes of this magnitude would make a significant difference to the estimates of the indirect impact of government expenditures and tax cuts reported in Table 3.14.

When the provincial economy is stimulated by the tax cuts and additional government expenditure it is implicitly assumed in the multiplier calculations that additional factors of production are available to the economy at current factor prices. The magnitude of the impacts of these fiscal measures suggests that sufficient additional factor supplies could not be obtained from pools of unemployed resources in Saskatchewan. The implicit assumption, therefore, is that factors will migrate from other regions even although factor prices remain unchanged. As was apparent in the review of booming sector models in Part 1 of this study it is unrealistic to assume in-migration of labour in the absence of a wage increase. The increase in wages which will be necessary to

attract labour to the government and nontraded goods sectors from other sectors of the economy and from other regions will raise the unit cost of production. This means that the estimates of Table 3.14 are overestimates of the real impacts of government policy on provincial GDPP.

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